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Dougherty, Edmond J.

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Ablaze Development Corp
771 E. Lancaster Ave, 2nd fl
Villanova, PA 19085-1519

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The scalable emergency system is intended to cover the full scale of possible at-sea incidents from the routine to the rare; from the detection and decontamination of a single piece of equipment before it is loaded on a vessel, to the response, rescue, containment and rehabilitation of a vessel in open waters. The system will be able to safely and quickly decontaminate cargo and personnel, as well as entire vessels at sea and in port. This report finalizes the top level design of the four (4) primary concepts selected for the program.

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19a. NAME OF RESPONSIBLE PERSON
Edmond J. Dougherty

19b. TELEPHONE NUMBER (include area code)
484-557-6590



**The Radnor Building 771 E. Lancaster Ave Second Floor
Villanova. PA 19085**

Program Officer
Attn: Katherine Mangum, Code 333
Office of Naval Research
875 N. Randolph Street
Arlington, VA 22203-1995

September 12, 2008

Subject: Report on Top Level Designs - Final, Contract N00014-06-C-0599

Dear Ms. Mangum,

In fulfillment of Contract Line Item No. 0001, Data Item No. A010, *Report on Top Level Designs - Final*, of Contract N00014-06-C-0599, *Feasibility and Top Level Design of a Scalable Emergency Response System of Oceangoing Assets*, attached please find a copy of the report.

If you have any questions or comment, please contact me at 484-557-6590 or edougherty@ablazedevelopment.com.

Very respectfully,

Edmond J. Dougherty
President

Ablaze Development Corporation
The Radnor Building
771 East Lancaster Ave
Second Floor
Villanova, PA 19085

Report on Top Level Designs - Final

In support of:

Feasibility and Top Level Design of a Scalable Emergency Response System for Oceangoing Assets

**Office of Naval Research Contract No. N00014-06-C-0599
Contract Line Item No. 0001, Data Item No. A010**

Submitted to
Program Officer
Attn: Katherine Mangum, Code 333
Office of Naval Research
875 N. Randolph Street
Arlington, VA 22203-1995

Submitted by
Ablaze Development Corp.
October 20, 2008

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Introduction

This report finalizes the top level design of the four (4) primary concepts selected for the program, *Feasibility and Top Level Design of a Scalable Emergency Response System for Ocean-going Assets*. The top level designs included in the report and organizations performing the work are as follows:

1. *Emergency Response Decontamination System*, Ship Recycling Research Institute.
2. *Chemical Warfare Agent Sensing and Remediation*, Villanova University.
3. *Microarray Identification of Pathogens*, Villanova University.
4. *Optical Fibers for Detection of Radionuclide Contamination*, Villanova University.

Chapter 1 – Emergency Response Decontamination System

Ship Recycling Research Institute

Executive Summary

According to the National Research Council, the Navy has largely focused on contamination prevention at the expense of decontamination¹. At the same time, the US Department of Transportation has documented more than 221 maritime incidents involving hazardous materials within the last 10 years.² This situation, coupled with astute and dynamic adversaries who will exploit gaps in U.S. capabilities, underscores the need for a robust, rapidly deployable consequence management and mitigation capability for CBRN accidents and CBRN attacks on U.S. warships, cruise ships, other commercial vessels, offshore energy production infrastructure, Sea bases, isolated PREPO sites and other offshore infrastructure that is vital to U.S. interests or national security.

The Emergency Response Decontamination System research is presented in three sections. Section 1 presents the concept of a three-phased scalable emergency response to an at-sea Chemical, Biological, Radiological, Nuclear (CBRN) event. The main text of the report provides detailed descriptions of equipment, personnel, configurations and timelines for all three phases. Section 2 introduces the Twenty-Foot Equivalent Unit (TEU) concept describing the decontamination response using a shipping container supply system. Section 3 is the project reach-back and the research and engineering components, proposed for the Philadelphia Navy Yard

¹ NRC-Naval Studies Board 2004

² Hazardous Materials Information System, U.S. Department of Transportation Table: Incidents By Mode and Incident Year <http://hazmat.dot.gov/pubs/inc/data/tenyr.pdf> (as of 3/2/2007)

Phase I of the Emergency Response begins with proactive, pre-event preparations:

- Require periodic basic chemical, biological, and radiological defense training for all Navy personnel.
- Enroll all Navy DC personnel in Damage Control “A” School
- Enroll all Navy DC personnel in a modified version of the US Army’s Chemical School training that addresses particular working environments and situations onboard a Navy vessel during a CBRN event.

When a CBRN event occurs, Phase I begins on the vessel and on-board personnel will act within the first 12 hours to perform the existing standard operating procedures established for response to an event and begin basic on-site cleanup.

In Phase II, the ‘Alpha’ Airborne and ‘Bravo’ Fast Response elements transport emergency and expert personnel and bring the structure and tools needed to further decontamination. Arriving within 12 - 48 hours of the incident, the Airborne evaluation team will provide additional emergency medical care and contribute specialized expertise in CBRN detection, decontamination and protection. The Fast Response team will deploy within 48 hours of the event from various pre-positioned locations around the world aboard a prepared vessel, such as a Landing Craft, Air Cushion (LCAC) or a Joint High Speed Vessel (JHSV). It will establish the Command and Control Office, secure the vessel, establish the operations chain of command and begin extreme decontamination operations.

Phase III goes into effect if the Commanding Officer determines that further decontamination is necessary. It begins no later than 3 weeks after the CBRN event. There are five options for Phase III implementation. The option selected will depend upon the severity of risk, site accessibility and the requirement of the vessel at port or at sea.

The basic premise of the TEU concept, presented in Section 2, is that every component of the response mission, from living quarters to laboratories to waste collection, will be packaged in individual TEUs that can be arranged on the deck of the ship. Within the TEU network, a series of corridor modules will provide infrastructure connections. Easy to transport and arrange, the 20-foot long metal shipping containers can be customized to serve any role of the emergency response system. Using a mix of new and existing capabilities, qualified personnel will conduct operations and respond to the event, using only the assets available in a TEU network. The main text of the report describes load-out scenarios and TEU specifications are presented in Appendix 4.

Implementation of the phased response system and the TEU concept will require a series of reach-back capabilities that are either missing entirely or interspersed across geographic, departmental and agency boundaries as well as the private and educational sectors. The report identifies three actions that should fulfill the need to unify and centralize reach-back capabilities:

1. Establish a design, fabrication, and maintenance facility for the modular TEU units that this project will use extensively
2. Develop a dedicated research and innovation cluster that draws together DOD personnel, university and other researchers, and the private sector.

Section 3 outlines how to move forward from the design phase, which will require a port with ship access and a TEU storage facility nearby. The report's port facility analysis shows that only five American port regions have the ideal combination of industry and labor force for project success. Based upon comparative analysis and data (Appendices 5-8), Philadelphia is the recommended port for project implementation. This section proposes using a business cluster framework to identify and connect the disparate industries needed to implement the project and to promote industrial and workforce development in the host community. Profiles of successful clusters illustrate the ways in which businesses, government agencies, and academic institutions can cooperate, leverage a natural resource, and network to increase the productivity of cluster companies, drive research and development and stimulate new business.

Recommendations

The Emergency Response Decontamination System research resulted in 68 specific recommendations to the US Navy in the areas of:

- Readiness Procedures
- Education and Training
- New CBRN Protocols
- Sustainability
- Decision Making
- Twenty-Foot Equivalent Units (TEUs) and Vessel Layout
- Personnel
- Operations Center
- Cluster Development.

The specific recommendations are presented below.

Category	Research Recommendations
Education and Training	<p>Increase CBRN training for Navy Damage Control personnel by extending length of training time and focus specifically on responding to onboard CBRN Events</p> <p>Obstacle: Currently only minimal CBRN event response training for Navy personnel</p> <p>Proposed Solution: Modify CBRN training courses from other branches to focus on different vessel types, sizes, and overall classification systems to identify constraints on</p>

Category	Research Recommendations
	<p>different vessels during a potential CBRN event.</p> <p>Obstacle: Existing first-response SOPs are not sufficient for a response to CBRN threats (SUPSALV method does not specifically address contamination).</p> <p>Proposed Solution: Modify CBRN training courses from other branches to focus on different vessel types, sizes, and overall classification systems to identify constraints on different vessels during a potential CBRN event</p> <p>Obstacle: CBRN training courses in other military branches are not specific to Naval situations (CBRN events onboard Navy vessels)</p> <p>Proposed Solution: Modify CBRN training courses from other branches to focus on different vessel types, sizes, and overall classification systems to identify constraints on different vessels during a potential CBRN event</p> <p>Obstacle: Navy is the only branch with no specific rating for personnel who can respond to CBRN contamination</p> <p>Proposed Solution: Navy should adopt Air Force's policy of designating more CBRN training for those in higher ranks</p>
Education and Training	<p>Navy DC CBRN training should continue to use training courses currently offered (basic CBRN and survival courses for all Navy personnel, DC "A" School for DC personnel, and periodic shipwide CBRN Unit Defense exercises)</p> <p>Obstacle: Time intensive; expensive</p> <p>Proposed Solution: Gradually incorporate changes; prioritize vessels going to high threat areas</p>
Education and Training	<p>Vessel wide DC training should include a section on CBRN readiness training.</p> <p>Obstacle: Current DC training focuses mainly on firefighting</p>
Education and Training	<p>CBRN training for Navy DC personnel should incorporate training courses used by other branches</p> <p>Obstacle: CBRN training in other branches does not specifically address response to CBRN contamination onboard a Navy vessel</p> <p>Proposed Solution: Modify Army CBRN Specialist training at Army's Chemical School to specifically address the Navy's DC personnel in response to CBRN events in particular working environments and situations onboard a Navy vessel.</p>
Education and Training	<p>Chemical Officer Basic Course should be modified to conduct training onboard various Navy vessels</p> <p>Obstacle: Time intensive; expensive</p>
Education and Training	<p>The Army's Biological Integrated Detections Systems (BIDS) Courses, Chemical Reconnaissance (Recon) Course, Radiological Safety (RADSAFE), Operational Radiation Safety (OPRAD), and Depleted Uranium (DU) awareness courses, Joint Senior Leader (JSL) Course, CBRN Mass Casualty Decontamination Course, and Civil Support Skills Course (CSSC) should be modified to provide training for Navy DC personnel</p>
Education and Training	<p>The Navy should use the Air Force deployment threat area system to prioritize training to vessels that are deployed to higher threat areas</p>
Education and Training	<p>The Navy should create refresher courses in CBRN defense and require DC personnel to take the refresher courses periodically</p>

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Category	Research Recommendations
Education and Training	The Navy should create a system to define which personnel will be most closely working on CBRN events and provide training accordingly
Education and Training	U.S. Coast Guard National Strike Force Weapons of Mass Destruction Technician Course should be modified to emphasize CBRN onboard oceangoing vessels and be offered to Navy DC personnel
Readiness Procedures	Vessel design should integrate technology to sense contaminants, protect the vessel, and respond to CBRN events, based on research of Capabilities Development Documents (CDD) and Capability Production Documents (CPD)
Readiness Procedures	As part of the vessel design integration process, CBRN processes should also be included within existing Navy systems such as the Joint Warning and Reporting Network (JWARN), the Hazardous Material Information Resource System in conjunction with Ship Class Database (HMIRS), and the Joint Acquisition CBRN Knowledge System (JACKS)
Readiness Procedures	<p>Purchasing procedures should be designed to protect the vessel, by ensuring that locally acquired equipment and materials are not introduced to afloat vessels.</p> <p>Obstacle: Risks economic and security benefits of buying locally</p> <p>Proposed Solution: Use Air Force threat area system and similar matrices to create an appropriate balance between economic interdependence and security of USN personnel</p>
Readiness Procedures	<p>All vessels should include standard equipment for preliminary decontamination (including PPE), rated for use in NBC-contaminated conditions, and all personnel be trained to use this equipment</p> <p>Obstacle: May be space/cost prohibitive.</p> <p>Proposed Solution: Prioritize vessels going to high threat areas</p>
Readiness Procedures	DC personnel should monitor and record the general state of the vessel, and address any safety concerns that arise
Readiness Procedures	Equipment for a CBRN response should be pre-positioned in Philadelphia, Diego Garcia, San Diego, Mediterranean Sea, and Guam/Saipan
Readiness Procedures	The roll-out schedule for the Pre-Po nodes should be staggered so that from Z-Year + 5.5 there will always be three active nodes on alert
New CBRN protocol	Evidence should be preserved, as well as the results of any early hazard identification tests.
New CBRN protocol	Incoming response forces should be notified of whether the contaminated vessel has the structural integrity to accommodate the helicopters and decontamination modules that would be dropped onto the vessel's deck as part of the airborne element
New CBRN protocol	After the Fleet has isolated the contaminated portions of the vessel and given detailed reports to the operations center, a formal evaluation team including shipbuilding engineers and a scientific advisory group should be dispatched to begin testing for CBRN contaminants
New CBRN protocol	Further containment of the CBRN material and the beginning of recovery and restoration should be conducted by the USMC CBIRF, consisting of Recon element, decon element, medical, limited security, service support, and a command and control element depending on the complexity and duration of the deployment
New CBRN protocol	The airborne element of the CBRN response should be triggered by the initial contingency, and deploy within 12 hours of the event
New CBRN protocol	The airborne element of the CBRN response should fly directly to the affected vessel and unload if possible

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Category	Research Recommendations
New CBRN protocol	<p>The Recon element of CBIRF should fly in the lead aircraft with the operation Commander, and should coordinate arrival, locate the HQ element, and detect, collect, and identify the contaminant.</p> <p>Obstacle: Recon element may be unable to identify the contaminant.</p> <p>Proposed Solution: If Recon cannot identify the contaminant, members should collect samples for available agencies to identify</p>
New CBRN protocol	<p>The Decon Element of CBIRF should provide decontamination of the vessel and any equipment exposed to CBRN agents</p> <p>Obstacle: Are there products available that could decontaminate the entire vessel?</p>
New CBRN protocol	<p>Support Element personnel should be assigned to one of four sections within the Element: the Headquarters Section should provide all command functions and act as a coordinating agency for the Element.</p>
New CBRN protocol	<p>The Embarkation Section of the Support Element should provide embark/debark support to all Elements from its permanent location to the incident site, and should be capable of arranging airlift and sealift to the site</p>
New CBRN protocol	<p>Security Element personnel should provide security for the other elements, maintaining lines of cordon, assisting with the evacuation of casualties, assisting fire control and detaining personnel as necessary</p>
New CBRN protocol	<p>A fast response vessel should deploy within 48 hours of the contingency from various forward locations around the world aboard a prepared vessel, such as an LCAC, JHSV, etc., according to the mission requirements</p>
New CBRN protocol	<p>The fast response vessel should tie off to the affected vessel, and should contain the core components necessary to begin operations on a full scale</p>
New CBRN protocol	<p>Both the airborne element and fast response element should operate under a unified scene commander to coordinate decontamination</p>
New CBRN protocol	<p>A vessel for a large-scale decontamination should load out 2-14 days (on average though very incident dependant) after the initial incident, and arrive on scene no more than three weeks after the incident</p> <p>Obstacle: System development and procurement will be costly</p> <p>Proposed Solution: Pre-Po roll-out schedule will be staggered to spread the costs over a period of 8-10 years and capitalize on lessons learned between now and deployment.</p>
New CBRN protocol	<p>Upon arriving at the contaminated vessel, the decontamination vessel should use sensors and robotics to conduct a scan of the affected areas</p>
New CBRN protocol	<p>Once the mission commander declares the decontaminated vessel to be clean and operational, the specialized equipment used for the decontamination mission should be reloaded aboard the delivery vessel and returned to port</p>
New CBRN protocol	<p>Upon demobilization, the decontamination equipment should be cleansed, repaired, resupplied and prepared again for deployment</p>
Sustainability	<p>The Support Element should be able to self-sustain the CBIRF for 10-14 days and arrange further logistical support to sustain operations, utilizing commercial-off-the-shelf (COTS) equipment whenever possible, as well as commonly available military systems that require little to no customization and are readily available within DOD</p>
Sustainability	<p>The Supply Section of the support element should provide supply and warehousing support to the CBIRF, ammunition support to the security element and assist in fiscal/contractor support services from aboard the affected vessel</p>
Sustainability	<p>The Engineer Section of the Support Element should provide water, utilities and heavy equipment support at the incident site.</p>

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Category	Research Recommendations
Decision Making	After the vessel is secured, the Commanding Officer should determine the best of a continuum of options for full-scale decontamination, based on the size and condition of the vessel, and the necessity of returning it to direct action
Decision Making	Option A occurs in-transit and consists of an airlift of necessary equipment to the site of a wet vessel, resulting in a return to port after basic decontamination
Decision Making	Option B, also in-transit, airlifts materials to a dry vessel, performing a mid-to-high level decontamination, resulting in a return to port
Decision Making	Option C is to sealift via decontamination vessel contingent, and perform a high level decontamination so the affected vessel is fully capable of supporting direct action
Decision Making	Option D accesses the site via sealift, and may occur when there is a restriction of decontamination capabilities, so the affected vessel can support direct action only if required; otherwise the vessel is returned to port for refit
Decision Making	Option E, used during emergency war-time only, sealifts equipment plus additional assets as needed and leaves the vessel as clean as possible within current strategic constraints so the vessel is returned to fleet at reduced capability for limited action.
Decision Making	The decontamination vessel should meet a baseline of specifications, including a speed of 15+ knots, sustainable in Sea State 3-4, displacement of 15,000 to 20,000 tons, range exceeding 3,000 nm, secure tie down points, helicopter operations/landing pad and external utility access
Decision Making	Choice of a decontamination vessel should depend on the decontamination option implemented by the Commanding Officer. Obstacle: There are some constraints with all three options of retrofitting an existing vessel, constructing a specialized DOD vessel, and using an existing vessel without retrofit
TEUs and Vessel Layout	The platform/transport vessel should carry a series of designated TEU modules, to be configured based upon the specifics of the situation to which the vessel is responding
TEUs and Vessel Layout	Baseline TEUs for a decontamination vessel should include a C4I/IO Cluster (3-6 TEUs), a Datacenter, 4 Housing modules, Waste/HAZMAT, First Aid/BLS, Office, 2 TEUs for Crane, and additional connector TEUs as needed
TEUs and Vessel Layout	Anterooms should be stationed at every entrance to the deck of the vessel allowing personnel to safely remove HAZMAT suits and to decontaminate before entering the larger network of TEUs.
TEUs and Vessel Layout	There should also be portable detection devices customized to the mission at every entrance to ensure that personnel remain uncontaminated
TEUs and Vessel Layout	The delivery vessel should also carry lab equipment for decontaminating sensitive shipboard electronics, as well as an isolation chamber for storing contaminated materials and clean-up related debris for transport to a safe-disposal facility
TEUs and Vessel Layout	A dedicated clean area onboard the vessel should be allocated to handle personnel and equipment as the platform/transport vessel operations move back and forth

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Category	Research Recommendations
TEUs and Vessel Layout	While the vessel is being decontaminated, the platform/transport vessel should also be able to provide housing for affected personnel via TEU-based units as well as basic utilities to augment those affected aboard the contaminated vessel
TEUs and Vessel Layout	Post operations all TEUs should be decontaminated on-vessel with preexisting methods and materials used for tank decontamination
Personnel	In addition to physical modules, the platform/transport vessel should leverage capabilities of specially trained and equipped teams from various agencies, including but not limited to personnel from the FBI, CIA, EPA, CDC and FDA
Personnel	Recovery in final phase of decontamination should be handled primarily by private decontamination and cleanup contractors, but a CBIRF team should remain to direct and oversee contractor recovery effort
Operations Center	Create a 24/7 one-stop Operations Center to respond to and coordinate response to a CBRN event anywhere that the Navy operates
Operations Center	The Operations Center should direct the mission, act as a communications line between the affected vessel and various government and civilian entities, and leverage resources available to increase the success of the decontamination operation
Operations Center	Standing personnel at the Operations Center should include Navy officers and enlisted personnel with ratings in a variety of support and communication positions, personnel from non-Navy participating entities acting as liaisons between the decontamination efforts and their agencies, and consultants
Operations Center	A close working relationship should be established between the Operations Center and the Philadelphia Center, with regular staff rotations, close consultation, and conferences.
Cluster Development	Develop a dedicated research and innovation cluster in the Philadelphia Navy Yard that draws together DOD personnel, university and other researchers, and the private sector
Cluster Development	Establish a design, fabrication, and maintenance facility in the Philadelphia Navy Yard for the modular TEU units that will be used in CBRN response
Cluster Development	The Navy Yard facility should create a TEU prototype, manufacture a small quantity of TEUs as needed, and post-operations will repair, restock, and complete any additional maintenance as necessary
Cluster Development	During manufacturing, each TEU should be tagged with a unique RFID code to aid in later maintenance

“We will continue to work to improve understanding and harmonize best practices amongst interagency partners. This must happen at every level from Washington, DC-based headquarters to the field. DoD, in partnership with DHS, also will continue to develop habitual relationships with state and local authorities to ensure we are positioned to respond when necessary and support civil authorities in times of emergency, where allowable by law. Through these efforts we will significantly increase our collective abilities to defend the homeland.”

– National Defense Strategy, 2008, p. 18

Introduction

The goal of this report is to develop a conceptual design for emergency at-sea response and decontamination of a Chemical, Biological, Radiological, and Nuclear (CBRN) event. This report has three sections:

- Section I. presents a phasing concept detailing a three-phased scalable emergency response to an at-sea CBRN event;
- Section II outlines a Twenty-foot Equivalent Unit (TEU) concept and describes the decontamination response using a shipping container supply system.
- Section III details a project reach-back and research component.

Section I. Phased Response System describes the phasing concept beginning with Phase I, detailing the current on-vessel and local response that could be expected if a CBRN event happened today. Phase I also recommends augmented training and roles for damage control personnel in order to create a better storehouse of local knowledge of the distinct elements of a CBRN event.

Phase II systematizes and codifies action using a two part response in which an evaluation team and then the Marine Corp’s Chemical, Biological Incident Response Force (CBIRF) lay the groundwork for thorough decontamination. If damage to the vessel is minor, Phase II may result in a return of the vessel to the Fleet.

In the event that additional decontamination is necessary, a supplemental Phase III provides a continuum of options for the completion of thorough decontamination, based on the condition of the vessel and the necessity for returning it to direct action. This capability is a significant departure from the current practice of cleaning up the event as best as possible and then towing the vessel to port for further action or if unsuccessful, sinking it.

Section II. TEUs and Modular Response explains the Twenty-Foot Equivalent (TEU) concept and the way shipping containers will be used as modular capability platforms to decontaminate and recover the affected vessel. This section also includes a description of the Command, Control, Communications, Computers, and Intelligence / Information Office (C⁴I/O) TEU. This unit and its accompanying data center module provide the interfaces that connect the various working parts of the response. These parts include other TEUs and agencies on scene, the operations and remote command centers involved in the operation and any other part of the Federal Government that needs to be involved.

Section III. Reachback Needs and Philadelphia describes the reach-back, operations, research and development, and maintenance functions that this project requires and synthesizes the analysis that underpins the compelling advantages of basing these structural aspects at the Philadelphia Naval Yard.

SECTION I. Phased Response System

Phase I: Local Response

Overview

Phase I will consist of pre-event preparations for and first-response actions to a contamination event. Ideally, Phase I will begin before an event, with increased training for the Damage Control ratings, and research into ship design as it concerns CBRN contamination. Currently, Damage Control personnel receive limited training in CBRN event response. Additional training is needed to improve response to contamination events. Also, potential contamination incidents should be taken into account when ships are designed or purchased. These acquisitions require consideration of systems and materials that can stop the spread of CBRN contaminants and simplify decontamination efforts.

In addition to pre-contamination planning, Phase I is in effect from the time of the contamination event H-Hour to H-Hour + 12 (or the arrival of Phase II personnel). Phase I will cover first response assistance to contaminated crewmembers and preliminary decontamination operations. Contaminated portions of the ship will be sealed; Personal Protective Equipment (PPE) will be worn. Any decontamination that can be done on the ship at this time should take place, including use of the wash down system and Collective Protection System (CPS), if it is present. Standard Operating Procedure (SOP) should be followed at all times to ensure the protection of the crew, as outlined in the Multi-Services Tactics, Techniques and Procedures for Nuclear Biological and Chemical (NBC) Protection document.³ Phase I duties will conclude with reports of ship stability and a general Situation Report, and preparations for Phase II. Triage and evacuation should be completed based on established Navy response procedures.

Pre-Event Preparations

By planning ahead and training personnel on the specific procedures in response to CBRN events, the Fleet will be able to improve their ability to address the event itself as well as all the issues and actions related to an incident on a ship. Personnel who are familiar with first-response SOPs and comfortable with the equipment and procedures are better able to prepare the ship for continuing decontamination while maintaining their own health and avoiding further contamination.

³ *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection*. FM 3-11.4 (FM 3-4). U.S. Army. June 2003.

Existing first-response SOPs are not sufficient for a response to CBRN threats. In the procedure outlined in the Navy Salvage Handbook⁴, the Surplus and Salvage (SUPSALV) method provides an adequate generalized response to hazardous materials spills. SUPSALV procedures direct the Navy On-Scene Coordinators (NOSC) and Navy On-Scene Commanders (NOSCDR) to stop pollution in their area of specialty fight fires and restore the watertight envelope. SUPSALV provides guidance to ensure the vessel's continued seaworthiness and prevent environmental pollution. However, it also illustrates the Navy's lack of a sustained effort to address the consequences of an incident that requires external aid⁵. A weakness of the SUPSALV method is that it does not specifically address CBRN contamination. While it provides guidance for small spills and low-level contamination responses, the Navy Salvage Handbook requires additional instruction or protocols to address more intensive contamination events.

CBRN Personnel Training

The Navy's personnel training system will also require modifications in order to strengthen the response to CBRN events. Currently, the Navy is the only division of the armed forces that does not have a specific rating for personnel who can respond to a CBRN contamination. There is no Navy Enlisted Classification (NEC) that specifically addresses NBC responses. Instead, squadron maintenance personnel and Seabees receive some training in emergency response.⁶ The Navy does use The Navy Occupation Safety and Health (NAVOSH) manual, which details the responses to particular accidents that may occur on a ship.⁷ The Navy Safety Center provides NAVOSH procedure training in a variety of locations, generally for one day, or over the course of several days for more intensive courses. However, NAVOSH does not explicitly cover CBRN events, and instead concentrates on asbestos, fire, spills, hazardous material and industrial hygiene issues. Although crewmembers are taught generally how to respond to hazardous accidents through this training, it does not provide the specific knowledge that CBRN decontamination requires.

In contrast, the Joint Service Family of Decontamination Systems (JSFDS) does have a Damage Control rating⁸, specifically tasked with an "all hands evolution to protect and preserve war fighting capabilities"⁹ and with training personnel in all aspects of damage control.¹⁰

⁴ *U.S. Navy Salvor's Handbook*. S0300-A7-HBK-010, 0910-LP-016-7750. U.S. Navy. January 1, 2004.

⁵ Naval Forces' Defense Capabilities Against Chemical and Biological Warfare Threats Naval Studies Board: National Research Council of National Academies 2004

⁶ *Seabee Combat Handbook 2*, NAVEDTRA-14235. Naval Education and Training Professional Development and Technology Center. July 2003.

⁷ *Course Catalog (FY08)*. Naval Safety Center. Accessed on December 17, 2007 via <http://www.safetycenter.navy.mil/training/tableofcontents.cfm>.

⁸ *Damage Control Skills and Tricks of the Trade*. NAVSEA. Naval Sea Systems Command. Accessed on August 6, 2007 via <http://www.dcfp.navy.mil/library/dctricks/DCTrick021.htm>.

⁹ *Navy Training System Plan for the Joint Service Family of Decontamination Systems Blocks I, II, III, IV*. N78-NTSP-A-50-0116/I. April 2002. 1-5.

¹⁰ *Damage Controlman Rating*. NAVEDTRA 14057-PPR. 1-5. Accessed on December 17, 2007 via http://www.globalsecurity.org/military/library/policy/navy/nrtc/14057_ppr_ch1.pdf.

Each member performing decontamination operations should be NBC-qualified by the U.S. Marine Corps Forces-Atlantic NBC School or a comparable institution. The Element's medical officer and corpsmen should be trained in the Medical Management of CBRN Casualties by the U.S. Army Medical Research Institute of Chemical Defense. Any member of the decontamination team not directly performing decontamination should be trained as an NBC Defense Specialist, for which there is a nine-week school at Fort McClellan.

Damage Control Personnel

Navy personnel, who handle shipboard emergencies such as fire, equipment malfunctions and other emergency repairs to the ship, including CBRN attacks, are known as Damage Control (DC) personnel. DC personnel also provide basic training to the remainder of those onboard to react to, handle, and carry out responsibilities during all of these types of emergencies.

Damage Control Training

Upon joining the Navy, all personnel receive basic chemical, biological, and radiological defense (CBR-D) training as outlined in the United States Navy (USN) Basic Military Requirements Naval Education and Training (NAVEDTRA) 14325 Training Course, chapter 13.¹¹ Training includes basic recognition of CBR attacks, the need for CBR defense and how best to respond to these attacks including the use of PPE, MOPP, CPS, and basic decontamination of the ship and its personnel. This training is meant to allow the ship to continue on as a combat capable force and properly use its protective systems, equipment, measuring devices, and continued training procedures against CBRN attacks. CBR-D training allows Navy units to survive CBR attacks and to continue to fight and defend their ship or unit under CBR-contaminated conditions.

Those who become Damage Control personnel attend Damage Control “A” School, a course “covering everything from shoring to decontamination training to firefighting.”¹² Available NAVEDTRA Damage Control Publication Manuals include such courses as Basic Military Requirements, Damage Controlman, Electrician, Engineman, Fireman, Personnel Qualification Standard (PQS) for Damage Control (DC), and First Aid courses.¹³

After going through “A” School, DC personnel are typically trained on the job with further formal training available as their careers progress.¹⁴ Further education takes place in the various rank-specific developmental education courses, as well as courses required

¹¹ *Basic Military Requirements NAVEDTRA 14325*. U.S. Navy. Feb 2002. Chap. 13. Accessed on October 29, 2007 via <http://compass.seacadets.org/pdf/nrtc/bmr/14325.pdf>

¹² Barnes, B. *Casualty Control*. U.S. Navy. Accessed on October 29, 2007 via <http://www.mediacen.navy.mil/pubs/allhands/jun99/pg16.htm>

¹³ *Damage Control Publications: Naval Education and Training (NAVEDTRA) Command Manuals*. NAVSEA. U.S. Navy. Accessed on October 31, 2007 via <http://www.dcfp.navy.mil/library/dcpubs/netm.htm>

¹⁴ Powers, Rod. Navy Enlisted Rating (Job) Descriptions and Qualification Factors, Damage Controlman (DC). 2007. Accessed on October 31, 2007 via <http://usmilitary.about.com/od/enlistedjob1/a/dc.htm>

of selected specialties. For example, a Navy course at Fort Leonard Wood is titled “Shipboard Chemical, Biological, Radiological Defense Operations and Training Specialist,” which provides basic to advanced CBR-D training for Enlisted Personnel (E5-E9), Officers, and Foreign Nationals. Graduates of the course will be prepared to conduct CBR-D training at training commands and aboard ship for functions necessary to prepare for, defend against and recover from CBR-D involvement.¹⁵

Preparing for and addressing CBRN attacks is just one portion of DC preparedness training. DC personnel are also responsible for the other emergencies that take place on a ship. Firefighting is highlighted during the DC “A” School.

Since DC personnel are required to be able to respond appropriately to chemical, biological, nuclear or radiological threats, the Navy needs to train them more extensively, implementing rigorous training over a long period of time and focus specifically on responding to onboard CBRN events.

As highlighted in the 2004 *Naval Forces’ Defense Capabilities against Chemical and Biological Warfare Threats* report, “Navy readiness for chemical and biological defense needs improvement. Sustained improvements toward remedying these deficiencies require establishing standards for readiness, training and exercising to those standards, and developing a reporting system attuned to this area. ...In fact, if the Navy chooses to implement only one recommendation from this report, it should be to commit to dramatically *improve readiness*.”¹⁶

Recommended Training for Damage Control Personnel

To improve readiness for CBRN events preparation, the Navy should continue to use several training courses currently offered and incorporate several training courses that other services require. These recommended changes will create a rigorous and prescribed program that brings the Navy’s CBRN training up to the advanced level needed for sufficient CBRN response preparation onboard oceangoing vessels.

Current Navy Training Recommended for Continuation

Table 1 lists individual Navy courses and unit Navy training programs, currently offered, that are recommended for continuation.

¹⁵ Shipboard Chemical, Biological, Radiological Defense Operations and Training Specialist. June 8, 2007. Accessed on November 2, 2007 via <http://www.wood.army.mil/navy/cbrd.htm>

¹⁶ Naval Forces' Defense Capabilities Against Chemical and Biological Warfare Threats. 2004: 8-9. Accessed on October 31, 2007 via http://www.nap.edu/catalog.php?record_id=11034.

Table 1: Navy Courses and Trainings Recommended for Continuation

INDIVIDUAL Navy Courses Recommended for Continuation	
Course	Navy Personnel to take course
Entry level CBR-D training that includes basic chemical, biological, and radiological defense CBR-D training as outlined in the USN Basic Military Requirements ¹⁷	All Navy personnel
Entry level PPE and survival skills training ¹⁸	All Navy personnel
Requirement to attend DC “A” School including the CBR-D element ¹⁹	All DC personnel
Disaster Preparedness Specialist (20 day) and CBR-D Shipboard Operations and Training (10 day) courses ²⁰	Required for those assigned to ship and shore billets that require specialized CBR-D expertise. These trainees then act as CBR-D trainers for their command. These should be taken by all DC personnel
UNIT Navy Trainings Recommended for Continuation	
Training	Navy Personnel to take training
Periodic CBRN Unit Defense training ²¹	All Navy personnel
Pre-deployment CBRN Unit training exercises	All deployable units
Basic and advanced CBR-D PQS training to take place after personnel report to units	Navy Units
Participate in ship-wide DC readiness training onboard Navy vessels; however, make sure a portion of the time is devoted to CBRN readiness training and not firefighting ²²	Navy Vessel

¹⁷ *Basic Military Requirements NAVEDTRA 14325*. U.S. Navy. Feb 2002: Chap. 13. Accessed on October 29, 2007 via <http://compass.seacadets.org/pdf/nrtc/bmr/14325.pdf>

¹⁸ *Department of Defense Chemical and Biological Defense Program. Annual Report to Congress*. April 2007: 111. Accessed on November 1, 2007 via <http://www.acq.osd.mil/cp/cbdreports/cbdpreporttocongress2007.pdf>.

¹⁹ Barnes, B. *Casualty Control*. U.S. Navy. Accessed on October 29, 2007 via <http://www.mediacen.navy.mil/pubs/allhands/jun99/pg16.htm>

²⁰ Ibid.

²¹ *Department of Defense Chemical and Biological Defense Program. Annual Report to Congress*. April 2007: 113. Accessed on November 1, 2007 via <http://www.acq.osd.mil/cp/cbdreports/cbdpreporttocongress2007.pdf>

²² *Damage Control Skills and Tricks of the Trade*. U.S. Navy. NAVSEA. Accessed on November 2, 2007 via <http://www.dcfp.navy.mil/library/detricks/DCTrick006.htm>.

Armed Services Training Courses or Programs Recommended for Inclusion

The Army, Air Force, Marine Corps and Navy maintain CBRN training elements at the United States Army Chemical School (USACMLS) in Fort Leonard Wood, Missouri. Currently, all CBRN defense specialist professional training, except for medical CBRN courses, are co-located at the Army's Chemical School for all services in accordance with Congressional statute (P.L. 103-160, Section 1702).²³ Despite this formal participation very few Navy personnel rotate through Ft. Leonard Wood and few of the trainings have been conceptualized with the limits and special considerations of Navy vessels in mind. The summation below describes best practices of the services active in the collaboration and elements that the Navy might profitably benefit from adopting and/or participating in.

Army

The Army's CBRN Specialists are the centerpiece of the Army's CBRN defense systems and formations. CBRN Specialists are embedded in every Army unit and receive 10 weeks of intensive CBRN training at the Army's Chemical School in Fort Leonard Wood, Missouri.²⁴

The Army CBRN Specialist training at the Army's Chemical School is the best option currently available to military personnel. The Navy's DC personnel should receive this training with modifications that *specifically address the Navy's DC personnel in response to CBRN events in particular working environments and situations onboard a Navy vessel.*

²³ Department of Defense Chemical and Biological Defense Program. Annual Report to Congress. April 2007: 99. Accessed on November 1, 2007 via <http://www.acq.osd.mil/cp/cbdreports/cbdpreporttocongress2007.pdf>.

²⁴ Department of Defense Chemical and Biological Defense Program. Annual Report to Congress. April 2007: 99-104. Accessed on November 1, 2007 via <http://www.acq.osd.mil/cp/cbdreports/cbdpreporttocongress2007.pdf>

Table 2: Recommended Ways In Which The Army's Chemical School Courses Can Meet the Navy's CBRN Training Needs

Army Chemical School Course	Course Description	Recommendation
Chemical Officer Basic Course (COBC)	Provides knowledge of radiation fundamentals, CBRN reconnaissance and decontamination operations, etc.	Conduct training onboard various Navy vessels.
Biological Integrated Detections Systems (BIDS) Courses	Training in biological identification and detection principles and required procedures.	Provide training to key Navy personnel to qualify them to perform biological identification and detection operations onboard Navy vessels.
Chemical Reconnaissance (Recon) Course	Training in CBRN identification and detection principles.	Provide training to Navy DC personnel. Note: Navy DC personnel do not need training on the M93A1 Fox CBRN Reconnaissance vehicle system because it will probably not be used on the vessel.
Radiological Safety (RADSAFE), Operational Radiation Safety (OPRAD), and Depleted Uranium (DU) awareness courses	Provides DC personnel the opportunity to learn decontamination procedures onboard various vessels. Acquire knowledge of fundamental radiological safety principles onboard a vessel	Provide training to Navy DC personnel
Joint Senior Leader (JSL) Course	DC Leaders further develop and reinforce skills and knowledge in the area of Chemical, Biological Warfare Defense, etc. Emphasis is placed on Joint CB Defense Fundamentals and doctrine (26 week course)	Provide training to Navy DC leaders
CBRN Mass Casualty Decontamination Course*	Provide DC personnel with casualty decontamination training onboard various vessels	Provide training to Navy DC personnel
Civil Support Skills Course (CSSC)*	Training for DC personnel in overall issues of a Weapons of Mass Destruction (WMD) incidents	Provide training for Navy DC personnel
*The CBRN Mass Casualty Decontamination Course and the Civil Support Skills Course are designed to train military personnel to assist local and state response assets by providing casualty decontamination to the civilian populace, and/or to assist an Incident Commander at a Weapons of Mass Destruction (WMD) incident. These courses could also train Navy DC personnel to respond to a CBRN event onboard a vessel. Again, the Navy would need to alter these courses so that they address the specific needs of Navy DC personnel when they respond to CBRN events onboard a Navy vessel.		

Air Force

The Air Force does not have any particular training courses that would enhance preparation of the CBRN response capability of the Navy's DC personnel. However, the Air Force does have several training mechanisms or situational factors that prioritize candidates for training.

Personnel deployment locations are ranked at High, Medium, and Low threat risk of CBRN attack. Those deployed to high risk areas are given more training.²⁵

Recommendation: All Navy personnel should receive the training outlined in Table 2 under Navy and Army CBRN training options. In addition, the Navy could use the Air Force deployment threat area system to give first priority to ships that are deployed to higher threat areas.

The Air Force requires recurring training every 20 months after the initial training to keep skills current and to introduce new or changed procedures.

Recommendation: The Navy should adopt this approach, create refresher courses for the Navy and Army courses listed in Table 2 and require DC Personnel to take the refresher courses.

The Air Force designates more CBRN training for those in higher ranks and based on command.

Recommendation: The Navy could use this concept to define who would be most closely and thoroughly working on given CBRN events and to train them accordingly. For example, since the DCA has a hand in all CBRN issues, they should receive a higher level of training.

Marine Corps

The Marine Corps has its own 12-week CBRN Defense Specialist Basic Course and 7-week CBRN Defense Officer Basic Course. The Marines utilize the Army's Chemical School for the majority of its additional CBRN training.

Recommendation: Because the Army is the lead military branch for CBRN training, Navy personnel should take the Army's courses rather than the Marine's CBRN Defense Courses.

Coast Guard

In 1973, the Coast Guard established the National Strike Force (NSF), a cutting-edge force of personnel and equipment that facilitates preparedness and response to oil and hazardous pollution incidents in order to protect public health and the environment.²⁶

²⁵ Department of Defense Chemical and Biological Defense Program. Annual Report to Congress. April 2007: 93, 105. Accessed on November 1, 2007 via <http://www.acq.osd.mil/cp/cbdreports/cbdpreporttocongress2007.pdf>.

They too are concerned with and are designated as respondents to WMD/CBRN issues. The Coast Guard also utilizes the Army's Chemical School CBRN training. A Coast Guard officer is assigned to the U.S. Army Chemical School to build a bond between the NSF and the Chemical School.²⁷ The Chemical School offers a *U.S. Coast Guard National Strike Force Weapons of Mass Destruction Technician Course*²⁸ that covers chemical, biological and radiological issues, as well as decontamination with field training exercises.

Recommendation: This course may be applicable to Navy DC personnel if it emphasizes CBRN issues onboard oceangoing vessels.

Damage Control Training Conclusion and Recommendations

An efficient and effective training regimen for the Navy's Damage Control personnel would combine courses and training programs from the Navy, Army, Air Force, Marines and the Coast Guard.

Specific Recommendations

- Continue the Navy's current required Damage Control-related training
- Require additional Army courses for select Damage Control Navy personnel as outlined in Table 2. These courses would be offered through the Army's Chemical School and CBRN Specialist training.
- Modify the Army's courses so they specifically address the Navy DC personnel response to CBRN events, in particular working environments and situations onboard a Navy vessel.
- Incorporate the Air Force system that provides additional training for personnel going to high-, medium-, and low-level deployment threat areas. In addition, Navy personnel going into higher risk areas should be trained first and receive a more thorough training with refresher courses recur every 20 months.
- Modify the Coast Guard's National Strike Force Weapons of Mass Destruction Technician Course to focus on CBRN issues onboard oceangoing vessels and offer it to Navy DC personnel.

Vessel Design and Purchasing Procedures

These preparations need to consider and integrate vessel design as well as account for materials and accessibility. Technology to sense contaminants, protect the ship, and respond to CBRN contaminations may be integrated into the ship's design, based on research of Capabilities Development Documents (CDD) and Capability Production

²⁶U.S. Coast Guard National Strike Force. U.S. Department of Homeland Security. Federal Emergency Management Agency. Accessed on November 2, 2007 via http://www.nimsonline.com/resource_typing/U_S_%20Coast%20Guard%20National%20Strike%20Force.htm.

²⁷ Branson, Dennis E. and Jaime Bigelow. *The Chemical Corps and the Coast Guard – Interoperability in Action*. Accessed on November 1, 2007 via <http://www.wood.army.mil/chmdsd/pdfs/2003%20Jan/Branson-Bigelow-03-1.pdf>.

²⁸ Stratman, Guadalupe. *Guardsman Train for Bio-terrorism at Leonard Wood*. TRADOC News Service and Web Operations. Accessed on November 2, 2007 via http://www.tsap.army.mil/pao/training_closeup/CGtrainFLW.htm.

Documents (CPD).²⁹ CDDs and CPDs are documents that assess, at the outset, the safety capabilities of new systems and equipment. These documents outline how various systems should be acquired, employed, and maintained to reduce hazards and Occupational Safety and Health (OSH) risk.

Purchasing procedures may also protect the ship, by ensuring that locally acquired equipment and materials are not introduced to afloat vessels.³⁰ Set forth in an existing SOP, this purchasing procedure illustrates a direction that CBRN preparation may take: building upon preexisting equipment, procedures and training. For example, fleet ships already have fully developed contingency plans required for oil spills. Contingency plans for CBRN emergencies can be developed by adjusting existing plans in ways that address the specific issues and needs surrounding a CBRN emergency.

As part of the ship design integration process, CBRN processes should also be included within existing Navy systems such as the Joint Warning and Reporting Network (JWARN),³¹ in conjunction with the Hazardous Material Information Resource System (HMIRS)³² and in conjunction with Ship Class Database and the Joint Acquisition CBRN Knowledge System (JACKS).³³

On-Vessel Incident Response

Onboard the affected vessels, Damage Controlmen are primarily responsible for responding to CBRN incidents.³⁴ They are trained to detect, confine and remove contaminants, but they also have the capability and charge to provide additional on-the-job training to other ratings. They maintain material readiness in damage control central and battle dressing stations to prepare for more advanced decontamination maneuvers. Because there are no enlisted personnel with a CBRN-ready rating, DCs will continue to fulfill this aspect of decontamination operations. However, the recommended training, as described in Table 2, should be implemented to increase their training in response to CBRN attacks.

Acting as Safety Officers, DCs will monitor and record the general state of the vessel, and address any safety concerns that either they themselves or personnel locate. They will also participate in hazard control. When an event occurs involving a hazardous material, they may isolate, ventilate and gain administrative control over that area, as

²⁹ *OPNAV Instruction 5100.24B*. Department of the Navy. Accessed on January 4, 2008 via http://www.safetycenter.navy.mil/instructions/OSH/5100_24B/5100.24B.pdf

³⁰ *Occupation Safety & Health*. OPNAVINST 5100.19D CH-1. Chap A4 Hazard Control & Deficiency Abatement. August 30, 2001.

³¹ *Joint Warning and Reporting Network (JWARN)*. NAVSEA. Naval Sea Systems Command. Accessed on April 30, 2007 via <http://www.dcfp.navy.mil/cbrd/ca/jwarn.htm>.

³² *Hazardous Materials Information Resource System*. Defense Logistics Information Service. Accessed on August 6, 2007 via <http://www.dlis.dla.mil/hmirs/default.asp>.

³³ *Joint Acquisition CBRN Knowledge System*. Joint Program Executive Office. Accessed on May 8, 2007 via <https://jacks.jpeocbd.osd.mil/>.

³⁴ *Navy Training System Plan for the Joint Service Family of Decontamination Systems Blocks I, II, III, IV*. N78-NTSP-A-50-0116/I: i. April 2002.

appropriate. DCs will also have been trained in the use of PPE, a skill that will also be needed in these first-response decontamination events.

Standard equipment will be included on all vessels for preliminary decontamination operations, and should be rated for use in NBC-contaminated environments. This includes PPE, as well as the attendant training for personnel to become comfortable wearing the equipment, and to get into and out of it safely. Other portable equipment should be trained for and available, such as portable decontamination showers, tents, backpacks with decontamination supplies, and other aspects of personnel decontamination. Because decontamination will often occur in high-stress situations, all personnel should be fully trained and comfortable using all possible equipment, including first-aid and first-responder techniques and materials.

Primary personnel decontamination consists of showering and application of M291 SDK. Decontamination stations should follow established procedure; gross decontamination before re-entering clean spaces, followed by the removal of outer clothing. Inner clothing should be removed as well, followed by showering and redressing in clean clothing.

Along with personnel response, ship's systems should be adjusted as needed to respond to contamination events. The ship's CPS, if installed, should be used to seal off areas necessary to the operation of the ship such as the bridge, engineering, and other vital areas that are uncontaminated. If the ship does not have a CPS, alternate methods should be utilized to continue the operation of the ship, if enough infrastructure and stability allows this possibility.

The Countermeasures Washdown System (CMWDS) should also be used at this time. The system is an efficient way to wash down some sections of the ship because it is easily activated and requires very little manpower. Due to ship design, however, the CMWDS should not be viewed as a thorough, systemic cleansing system. The system is unable to reach approximately 40 percent of the ship. In addition, water would damage parts of the ship such as the control tower and any sensitive equipment. Finally, the design of the superstructure of the ship makes complete cleaning impossible. The CMWDS is a good way to begin decontamination operations. However, to complete ship decontamination, more stringent measures will need to be implemented in later phases.

Procedures may be broken down into small- and large-scale hazard response. The DC is responsible for the initial response. In a small-scale hazard situation, the DC will assign a Risk Assessment Code (RAC) and may fix the situation if possible. If not, the DC will record it³⁵ and initiate the chain of command to remediate the situation. Larger-scale hazards require the Hazard Abatement Project Development and interim measures to be put into motion during Phase I.³⁶

³⁵ Incident should be documented per 5100.23G. *Navy Safety and Occupational Health Program Manual*. OPNAVINST 5100.23G. U.S. Navy. 30 December 2005.

³⁶ Ibid.

Once the contamination event has been identified, general and chemical alarms will be sounded by the officer of the deck, proposed decontamination sites will be designated, the CBRN threat assessed, and the defense plans developed per unit should be implemented (dispensing Individual Protective Equipment (IPE), and available detectors).³⁷ Mission Oriented Protection Posture (MOPP) will be determined and implemented, and CBRN detectors activated. Personnel should monitor status of NBC supplies and after preliminary stabilization is complete, crew should respond in the established manner for the type of CBRN decontamination, if it is known.

The Army, Marine Corps, Navy, and Air Force “Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection”³⁸ is a reference manual for addressing CBN attacks and “Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination”³⁹ can be referenced for decontamination principles and practices.⁴⁰

After initial post attack operations, reports will need to be gathered, to document the procedures taken so far and to inform the members of Phase II. Evidence should be preserved per SOP, as well as the results of any early hazard identification tests. If any crewmembers were exposed, effects they suffered should be included in the report. Any decontamination processes already done should be listed as well, e.g., a CMWDS wash down. A report on the security situation will need to be prepared for incoming forces, including the continued security level of the ship.

Integration

Once preliminary decontamination is complete, the crew and officers should prepare for integration with Phase II, a two part response, which includes an airborne element and a fast response element that facilitates the arrival of supplementary decontamination personnel and materials. It is estimated that there will be 12 to 48 hours between the time of the incident and the arrival of Deuce Alpha, the airborne element. The estimated arrival time of Deuce Bravo, the fast response element, is 48 hours to two weeks after the incident. Specific information will need to be communicated to these personnel, much of it similar to the reports made during preliminary decontamination and triage. In addition to these early reports of tests, reactions and the decontamination already begun, incoming forces will need to know if the contaminated ship has sufficient structural integrity to handle the helicopters used in the airborne element, in addition to possible decontamination modules that could be dropped on the ship’s deck. (If the ship’s deck is not stable enough to hold foreign objects, the airborne element will not be deployed.) No preparations are envisioned to be necessary to handle the Landing Craft, Air Cushion

³⁷ *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection*. FM 3-11.4 (FM 3-4). U.S. Army: 29-59. June 2003.

³⁸ *Ibid.*

³⁹ *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination*. FM 3-11.5. U.S. Army. 4 April 2006.

⁴⁰ This information is not meant to supersede other guidance contained in service-specific TTP or technical Publications.

(LCAC) that will come with the fast response element. Incoming forces will need a complete situation report.

Existing SOP for changing the chain of command will hold with the arrival of Deuce Alpha and the reordering of command. Likewise, no particular changes will need to be made to accommodate the extra personnel who will arrive with Phase II, because they will bring subsistence supplies with them. Casualty triage will have been completed before Phase II goes into effect.

Phase II: Emergency and Expert Response

Overview

After the Fleet has isolated the contaminated portions of the vessel and given detailed reports to the operations center, a formal evaluation team will be dispatched. The evaluation team, comprised of shipbuilding engineers and a scientific advisory group, will be dispatched with sophisticated equipment to begin the testing process for CBRN contaminants.

Further containment of the CBRN material in the second part (or Bravo element) of Phase II and the beginning of recovery and restoration will be conducted by the United States Marine Corps (USMC) CBIRF. Established at Camp Lejeune in 1996 and now housed within the National Capitol Region, CBIRF's mission is to assist Combatant Commanders (COCOMs) in consequence management operations by providing capabilities for agent detection and identification, Search and Rescue (SAR), personnel decontamination and emergency medical care and stabilization of contaminated personnel.⁴¹

A standard CBIRF deployment consists of five elements.

(1) Reconnaissance (Recon) detects the location, range and scope of an incident site, and coordinates the arrival of this phase's assets on scene.

(2) Decontamination (Decon) decontaminates personnel to begin life support operations and cordons and isolates equipment exposed to contaminants.

(3) Medical conducts casualty triage during and after decontamination and arranges for their medical evacuation (MEDEVAC).

(4) Security (limited) ensures lines of cordon with additional external security provided first by the contaminated vessel and Fleet escorts and then by the fast response element's fire control systems, whether organic or containerized.

(5) Service Support provides shelter, food and water to sustain the CBIRF on a contaminated vessel.

⁴¹ *Chemical/Biological Incident Response Force (CBIRF)*. [www.Global Security.org](http://www.globalsecurity.org). Page last modified: 26-04-2005. Accessed on December 21, 2007 via <http://www.globalsecurity.org/military/agency/usmc/cbirf.htm>.

A sixth Command and Control Element⁴² is added, depending upon the complexity, size and duration of the deployment. The Command and Control Element, is “CBIRF’s central nervous system,” consisting of operations, intelligence, administration and communication systems that coordinate all of the elements.⁴³

The particular strengths of the National Response System (NRS) model which carries over to Phase III, include a superior integration of authority and agencies. Within the model, a clear chain of command exists, with the Operations Commander able to request assistance from the Fleet Commander in Chief, who then gains control of the operations for the duration of the salvage procedure. Command reverts to the original Commander at the end of salvage operations, or if resources are not available to the Fleet Commander, they can be requested from, or authority may be handed over to, the Commander, Naval Sea Systems Command (COMNAVSEASYS COM)⁴⁴.

Delivery Response

Phase II will mobilize the initial response, beginning with the airborne element (Deuce Alpha) that will gauge the situation. The initial airborne response will be followed by a fast-response vessel containing expanded capabilities including the C⁴I/O (Command, Control, Communications, Computers, and Intelligence/Information Office) and the ability to provide interim life support, if necessary, pending medical evacuation (Deuce Bravo).

The two elements will have the ability to work together to quickly obtain information about the situation, and then use that knowledge to begin the decontamination operation. This phase, particularly Deuce Bravo, will focus on the decontamination operations moving from an emergency contingency to an organized operation, with the arrival of a new Commanding Officer specifically tasked with overseeing ship decontamination. With the early response capabilities of the Phase II twin elements, contamination will be more quickly contained.

DEUCE ALPHA / IIA (Phase II – Airborne ‘Alpha’ Element)

The ‘Alpha’ element will be the first external response unit on scene. The crew onboard and Fleet escorts will have performed those tasks possible to secure the vessel and its watertight envelope, and will provide primary intelligence on the vessel and its contaminants. The airborne element will provide specialized expertise in CBRN detection, decontamination and protection. The airborne element will be able to deploy within 12 hours of a contingency with H-Hour shortly thereafter.

The Deuce Alpha component will deploy via air. Preferably, the airborne element will fly directly to the affected ship and unload, dependent upon the contaminated vessel class.

⁴² Counterproliferation Program Review Committee CPRC Annual Report to Congress 1997. Accessed on January 2, 2008 via <http://www.fas.org/spp/starwars/program/cprc97/cprc9708.htm>.

⁴³ Ibid.

⁴⁴ *Salvage and Recovery Program*. OPNAVINST 4740.2F. Department of the Navy. July 10, 1997. Accessed on December 21, 2007 via http://www.combatindex.com/mil_docs/pdf/opnav/4700/4740-2F.pdf.

The aircraft outlined in Table 3 are examples of those that could be used for Deuce Alpha based on cargo size, range, speed and load needs.

Table 3: Airborne Lift Comparisons

Aircraft	Cargo	Range	Speed	Load
C.5 Galaxy	143'9"x19'x13'6"	6320nm	450 knots	270,000 lbs palletized cargo, 291,000 lbs max wartime payload
C.17 Globemaster III	88'x18'x12'4"	2400 nm	489 knots at 28000'	164,900 lbs palletized cargo, 170,900 lbs max wartime payload
MV.22 Osprey	None given	2289 nm on Self-Deployment, 99.4 nm on assault missions	257 knots	20,000 lbs internal OR 15,000 lbs external
CH.46E Sea Knight	None given	132 nm	145 knots	4,000 lbs external
CH.53E Super Stallion/MH.33E Sea Dragon	None given	CH:540 nm MH:700 nm	150 knots	36,000 lbs external
CH.47D Chinook	None given	unlimited w/refueling	130 knots, 170 knots max	28,000 lbs external
MH.53J Pave Low III/MH.53M Pave Low IV	None given	600 nm	143 knots at sea level	20,000 lbs external

DEUCE BRAVO / IIB (Phase II – Fast Response ‘Bravo’ Element)

The ‘Bravo’ element will also be triggered by the initial contingency. Aboard the fast response vessel, a standardized set of core response capabilities will provide a command and control structure and the tools necessary to commence decontamination operations. The fast response element will bridge the gap between the initial airborne element and a larger, tailored modular response, Phase III, which will arrive sometime after H-Hour +14 if the Commanding Officer determines that decontamination beyond Phase II capabilities is necessary.

The Deuce Bravo will deploy within 48 hours of the contingency from various forward locations around the world aboard a prepared LCAC..⁴⁵ A high-speed, over-the-beach fully amphibious craft capable of carrying a 60-75 ton payload, the LCAC will be assigned to transport equipment and personnel for the Bravo element. It is used to transport weapons systems, equipment, cargo and personnel. The LCAC can transport large quantities of food, supplies and medicines, and can conduct evacuations in areas previously accessible only by helicopter.

The LCAC’s drawbacks are its limited size, which increases the likelihood of ‘cubing-out’ (i.e., it cannot be loaded to full weight capacity), the difficulty of transferring cargo, and its limited rough sea capabilities. A well deck ship, or one equipped with material handling equipment or an intermediate platform, would not have these drawbacks. However, at this time, the LCAC’s speed and amphibious aspects make it the preferred craft for this phase of operations.

⁴⁵ *Landing Craft, Air Cushion (LCAC)*. Federation of American Scientists (FAS) Military Analysis Network. Updated February 14, 2000. Accessed on December 21, 2007 via <http://www.fas.org/man/dod-101/sys/ship/lcac.htm>.

The rapid response load-out will contain the core components necessary to begin operations on a full scale in anticipation of any Phase III components. This vessel will tie off to the contaminated vessel.

Phase II Personnel

The personnel accompaniment will be drawn primarily from various components across the Navy and Marine Corps after appropriate additional education and training. It will include mostly corpsman and enlisted personnel, but also Medical officers and Surface Warfare Officers (SWOs). Deuce Alpha will mobilize to begin conducting operations and managing the various components of this response. The core CBIRF personnel will largely comprise the Deuce Bravo element.

CBIRF typically deploys a 100 to 120 member response team, which maintains a 24-hour readiness posture, to a terrorist incident. CBIRF has the capability to add an additional follow-on force (FOF) of personnel if necessary. The purpose of Deuce Bravo is to deploy a small survey group from CBIRF to conduct the initial stabilization work and prepare reports on the severity of the incident. To fulfill these purposes, Deuce Bravo will mobilize a 25-member team across the CBIRF disciplines to extend the footprint and capabilities of the airborne team and prepare for Phase III operations if necessary. The five CBIRF disciplines will consist of the following personnel:

- Recon – 8 Enlisted; 2 Corpsmen; 1 Medical Officer
- Decon – 2 Enlisted
- Medical – 3 Corpsmen; 1 Physician; 1 Environmental Health Specialist; 1 Nurse
- Security – 2 Infantry Marines
- Support – 1 Enlisted (HQ); 1 Enlisted (Engineering); 1 Enlisted (Embark); 1 Enlisted (Supply)

The following C⁴I/O personnel will operate the systems contained within that cluster to support the CBIRF HQ component that will provide the command and control leadership upon arrival of the rapid response vessel:

- AECF – Advanced Electronics Computer Field
 - ET – Electronics Technician
 - FC – Fire Controlman
- IC – Interior Communications man (Advanced Technical Field)
- IS – Intel Specialist
- IT – Information System Technician

Aircrew personnel will also be necessary to operate and maintain the aircraft necessary for mobilization. Each aircrew will consist of 2 pilots and a loadmaster and maintenance personnel as determined. The rapid response vessel will similarly require a crew befitting its usual accompaniment.

CBIRF Elements

The Recon Element will fly in the lead aircraft with the operation Commander. Recon will coordinate arrival, locate the HQ element detect, classify and identify the

contaminant. If they are unable to identify an agent with their equipment, members will collect samples for available agencies to identify. In addition to detecting, collecting and identifying, Recon also determines which level of protective gear is necessary for follow-on teams.

The Decon Element is typically responsible for the decontamination of personnel and casualties. For the purposes of this report, Decon will be used to decontaminate the vessel and any equipment exposed to CBRN

The Medical Element is tasked with any arising medical issues. The staff can administer antibiotics and antidotes, and treat chemical burns and conventional injuries. Members of the Medical element will go into an affected area to provide on-scene, life-saving medical attention. Once they stabilize casualties, the element will evacuate them to available land-based medical facilities or hospital ships.

Support Element personnel are assigned to one of four sections within the Element (Typical CBIRF units also have a Motor Transportation Element⁴⁶).

1. The Headquarters Section provides all command functions and acts as a coordinating agency for the Element.
2. The Engineer Section provides water, utilities and heavy equipment support at the incident site. Its inventory includes Reverse Osmosis Water Purification Units (ROWPUs)⁴⁷, a variety of generators and heavy equipment.
3. The Embarkation Section provides embark/debark support to all Elements from its permanent location to the incident site. Since the CBIRF deploys to a site in the most expeditious means available, the Embarkation Section has to be capable of arranging airlift and sealift for the site.
4. The Supply Section provides supply and warehousing support to the CBIRF, ammunition support to the security element and assists in fiscal/contractor support services from aboard the affected vessel. In Supply, a contracting specialist has the ability to procure logistical support from other vessels within the Fleet as well as land-based distributors and contractors as necessary.

With these respective sections, the Support Element is able to provide housekeeping support for the CBIRF as well as limited support to the affected vessel. In a deployed status, the Support Element can self-sustain the CBIRF for 10-14 days and arrange further logistical support to sustain operations. The CBIRF utilizes commercial-off-the-shelf (COTS) equipment whenever possible due to ease of acquisition and lower relative costs. They also will utilize commonly available military systems that require little to no customization and are readily available within Department of Defense (DOD).

Security Element personnel will be tasked with providing security for the other elements, maintaining lines of cordon, assisting with the evacuation of casualties, assisting fire control and detaining personnel as necessary.

⁴⁶ Ibid.

⁴⁷ Ibid.

Integration

Upon the arrival of Deuce Bravo between H-Hour +48 and two weeks after the incident, the personnel from both detachments will begin to operate under a unified scene command to coordinate decontamination and determine the necessity of implementing Phase III. Phase II will secure the ship, establish an operations chain of command, and evaluate the extent of the damage to the vessel, allowing any Phase III personnel to focus on further decontamination of the ship and equipment.

Once the Commanding Officer decides to implement the supplemental Phase III, all operations will move to the Phase III vessel and full-scale operations will commence. Primarily, Phase II will have prepared the ship for complete physical decontamination and returning the ship to the Fleet or commercial owning entity.

Phase III: Thorough Decontamination Response

Overview

If the CO determines that further decontamination is necessary, a Phase III component will follow Phase II activities. The Phase III delivery vessel must be prepared to swiftly access the site, sustain itself and the crew of the affected vessel, and perform its mission at any location around the world. For this mission set, the delivery vessel must meet a baseline of performance specifications that will best facilitate the completion of the mission including speed, range, stability, power, capacity, etc. Additional details are presented in the “Delivery Options” section. Phase III is a continuum of options that depend on the size of the vessel, the level of cleanliness and decontamination required, and the necessity of returning to direct action. Each option fulfills four objectives: accessibility, sustainability, performance, and results.

The Phase III vessel will load-out at as soon as two days after and no later than 1 week after the incident. It will depart shortly thereafter, arriving on scene at most three weeks after the incident, at which point all Phase II operations will move to the Phase III vessel and full-scale operations will commence. All units will operate under the guidance provided under each TEU module description and answer to the scene commander.

Phase III A occurs in-transit and consists of an airlift of necessary equipment to the site. The Phase III A outcome is a wet variant return to port after basic decontamination. Phase III B, also in-transit, airlifts materials to the vessel, performing a mid-to-high level decontamination. The outcome is a dry variant return to port. Phase III C will sealift via decontamination vessel contingent, and perform a high level decontamination so the affected vessel is fully capable of supporting direct action. Phase III D accesses the site via sealift as well, and may occur when there is a restriction of decontamination capabilities, so the affected vessel can support direct action only if required; otherwise the ship is returned to port for refit. Phase III E, used during emergency war-time only, sealifts equipment plus additional assets as needed and leaves the vessel as clean as possible within current strategic constraints so the vessel is returned to fleet at reduced capability for limited action.

The platform/transport vessel departs from port with relevant modules onboard based on Situation Reports received from the Phase II quick-response team. The platform/transport vessel is envisioned as a “floating HAZMAT truck,” carrying a series of designated TEU modules. These standard-sized modules are designed for easy transport and activation at the site of the incident. They offer a range of options, to be configured based upon the specifics of the situation to which the vessel is responding.

The following TEU modules are the recommended baseline for a decontamination of a vessel:

C ⁴ I/O Cluster	(3-6 TEUs)
Datacenter	(1 TEU)
Housing	(4 TEUs)
Waste/HAZMAT	(1 TEU)
First Aid/Basic Life Support (BLS)	(1 TEU)
Office	(1 TEU)
Crane	(2 TEUs)
Additional ‘connector’ TEUs	As Needed

The delivery vessel will carry an accompaniment of laboratory equipment for decontaminating sensitive shipboard electronics, as well as an isolation chamber for storing contaminated materials and clean-up related debris for transport to a safe-disposal facility. Other TEU-based space, such as habitability modules, provides additional life supporting space and will also be a part of the complement.

Within the TEU network, a series of corridor modules would provide infrastructure connections. Power, breathable air, potable water and secure communications will all have identical ruggedized input/output (I/O) points in the TEUs (with a handful of exceptions for safety reasons, e.g., in the decontamination module), allowing a common design to be used, for all of the modules, in delivery and physical arrangement of the modules.

Upon arriving at the contaminated vessel, the platform/transport vessel uses sensors and robotics to conduct a scan of the affected areas. A testing unit confirms the prior evaluations of the incident and the TEU-based modules. A dedicated clean area onboard the vessel is allocated to handle personnel and equipment as the operations of the platform/transport vessel move back and forth. While the vessel is being decontaminated, the platform/transport vessel is also able to provide housing for affected personnel via TEU-based units as well as basic utilities to augment those affected aboard the contaminated vessel.

Once the mission commander declares the decontaminated ship to be as clean and combat capable as determined necessary, the specialized equipment used for the decontamination mission is reloaded aboard the delivery vessel and returned to port. Upon demobilization, the equipment will be cleansed, repaired, resupplied and prepared again for deployment.

Delivery Options

If the Command Center determines that Phase III A is most appropriate, necessary equipment will be airlifted to the contaminated vessel and the decon will occur in transit. The decontamination vehicle will be sustained by the pre-positioning vessel and security comport with USN Tactics, Techniques and Procedures (TTP). Solutions range from basic containment to mid-level decontamination en route to port. The outcome of this option is a return to port clean enough that the ship will be accepted for entry.

If the contaminated vessel is able to float or move independently, Phase III B may be employed. Phase III B is also an in-transit variant in which the decon vehicle will be sustained by the affected vessel. The decontamination effort will be high-level and possibly completed en route to port.

Phase III C may be used if a full scale decontamination is required. Phase III C involves a sealift via the decontamination vessel contingent. The decon vessel will be organically sustained with a 21-day supply of food, equipment, decon and waste containment gear. A high-level decon will be performed at-sea so the contaminated vessel is at minimal safety risk and fully capable of supporting direct action.

Phase III D consists of a large scale decon, also by sealift via decon vessel contingent. This vessel is organically sustained as well. This option may be prohibitive due to the complexity of the decon or the size of the vessel. If possible, decontamination efforts should be completed at-sea so the vessel can return to direct action if required. The affected vessel may be returned to port if unable to support direct action.

Phase III E occurs during war-time emergency situations when the vessel is required to return to fleet at a reduced capability for limited action. Decon equipment will be delivered via sea-lift, and additional assets may be transported as needed. The decon vehicle will be externally supplied and sustained with pre-po stocks, plus any additional supplies. The ship will be returned to action as clean as possible, but may pose a severe safety risk for personnel.

The delivery option determined by the Command Center will be dependent on the level of decontamination needed to fit the standards of cleanliness required for the outcome action. If the contaminated vessel is required to return to direct action and a severe risk to personnel is allowable, a low level of decontamination is necessary. If the vessel must return to port and there must be minimal risk to humans for permission to enter, a high level of decontamination is essential.

Standards of Cleanliness⁴⁸

Minimal Risk: Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing more than:

- Mild transient adverse health effects
- Discomfort, irritation, or certain asymptomatic, nonsensory effects
- Perceiving a clearly defined objectionable odor

Moderate Risk: Moderate risk is an acceptable concentration for unpredicted, single, short-term exposure of the general public in emergency situations. The risk includes maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing more than:

- Possibility of irreversible or other serious, long-lasting, adverse health effects
- Impaired ability to escape

Severe Risk: Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing more than:

- Notable discomfort
- Impaired ability to escape
- Irreversible or other serious, life threatening effects or death

Levels of Decontamination

Low-Level Decontamination: Basic Containment

- Elimination of threat to human life
- Managed exposure
- Special equipment may be required
- Long term health effects unknown but assumed negative

Mid-Level Decontamination: Large Scale

- All contaminants contained and human exposure at “acceptable risk”
- Special categories of population may see deleterious effects with long term exposure

High-Level Decontamination: Complex

- Longitudinal studies would show no discernable difference between long term exposed group and control population

⁴⁸ Definition of PACs. Accessed on February 21, 2008 via <http://www.atlintl.com/DOE/teels/teel/teeldef.html>

Table 4. Phase III Decontamination Options

	Accessibility	Sustainability	Decon Performance	Cleanliness Level After Action	Results
Phase III A. In-Transit Variant Wet	Airlift to site	Existing Pre-Po vessel and security comport with USN TTPs	Solutions ranging from basic containment to large scale decon en route to port	Moderate Risk	Return to port "clean enough" so that port will accept vessel; comport with nuclear incident TTPs
Phase III B. In-Transit Variant Dry	Airlift to site	Existing Pre-Po vessel and security comport with USN TTPs	Approaching complex decon Job may be possibly completed prior to return to port Result possible in transit	Minimal to Moderate Risk	Return to port "clean enough" so that port will accept vessel; comport with nuclear incident TTPs
Phase III C. At sea Full Scale Decon Variant	Sealift via decon vessel contingent Fast vessel	Organically sustained with 21 day supply decon solutions: food, equipment, decon gear, repair gear, waste containment	Complex decon at sea	Minimal Risk	Fully capable of supporting direct action
Phase III D. At sea Large Scale Decon Variant	Sealift via decon vessel contingent	Organically sustained with 21 day supply decon solutions: food, equipment, decon gear, repair gear, waste containment	Scale may be prohibitive If possible/required, complex decon at sea (CVNs and SuperMax)	Moderate Risk	Fully capable of supporting direct action only if required, otherwise returned to port for refit
Phase III E. Rapid Release Variant	Sealift plus additional assets as needed	Externally supplied and sustained with Pre-Po stocks plus any additional availables (all hands)	As clean as possible within current tactical/strategic constraints	Severe Risk	Returnable to fleet at a reduced capability for limited action (war-time emergency only)

Delivery Vessels

Flexibility is the hallmark of the Phase III response. Multiple TEUs provide collective protection and decontamination and four potential delivery scenarios provide ample options to transport the best systems and personnel to decontaminate a vessel and return it to the fight.

The Phase III delivery vessel must be prepared to rapidly deploy, sustain itself and the crew of the affected vessel, perform its mission and redeploy, in operational scenarios across the spectrum of conflict. For this mission set, the delivery vessel should meet a baseline of specifications that will best facilitate this capability.

- Speed of 15+ knots
- Sustainable in Sea State 3-4
- Displacement of 15,000 to 20,000 tons
- Range exceeding 3,000 nautical miles (nm)
- Secure tie down points
- External utility access
- Capable of Helo Ops/Landings

Potential Vessel Delivery Options

The vessels selected in Phase III have a tremendous impact on the ability to access the contamination site and the success of the decon effort. This section outlines the vessel options available and the convenience and constraints of each. Vessel preference may

vary, depending on whether Phase III C, D or E is implemented. Retrofitting an existing vessel may be the most practical for Phase III C and D, while using an existing vessel without retrofitting is likely to be the fastest response for option E.

Option 1. Retrofit existing Commercial or Navy Vessel (Individual or Ongoing Usage)

This option uses existing DOD contracts or vessels with large-scale transport capabilities to deliver the Phase III manpower and materials. **Conveniences:** There are a host of vessels that have the range, lift ability, deck area, carrying capacity and space for wash down. TEUs would be prepositioned in warehouses for deployment after the vessel is placed under contract for timely and inexpensive response.

Constraints: By virtue of different demands, commercial vessels inherently lack organic CBRN air handling and containment systems among other needs and could possibly become contaminated during the mission, which could be hazardous for ship and crew. Making alterations to the vessel for the mission, after agreeing to lease terms, would also be costly, time intensive and involve significant engineering challenges.

Option 2. Construct a Specialized DOD Vessel

This option ensures that the vessel meets necessary requirements and commanders are not constrained by payload, speed or stealth. This vessel will have the ability to enter the area, carry the needed payload and depart. **Conveniences:** It will be a next generation vessel with premier, state-of-the-art systems for navigation, firepower and stability, specifically constructed to operate in a contaminated environment. The ship can support and protect the crew, as well as handle incoming contaminated personnel.

Constraints: Designing and building this vessel will be extremely expensive and time consuming; redesigns of existing hulls alone are estimated to be between US\$500M and US\$1,000M.

Option 3. Use Existing Commercial or Navy Vessel Without Retrofit

Utilization of an existing vessel on an as-needed basis permits inexpensive delivery of needed equipment and personnel to the contaminated vessel. **Conveniences:** This option provides a range of available ships for use at various locations, allowing for quicker arrival. **Constraints:** This vessel may not contain all the ideal components that a specialized vessel offers, and may be costly to adapt or adjust the ship so it fits the delivery needs of Phase III. Loading and setup of TEUs and other materials may require extra time and manpower, however proximity of the vessel can compensate for these needs.

Table 5: Maritime Lift Comparisons

Maritime Vessel	Speed	Capacity	Length	Beam	Displacement	Notes
LCAC – Landing Craft, Air Cushion	40+ knots w/ payload	60 tons; 75 tons at Overload	88'	47'	200 tons at full load	
JHSV - Joint High Speed Vessel	35-48 knots	none given	313' – 410'	n/a	8,000 tons	Currently being leased; however, scheduled for delivery in the near-term
Rapid Strategic Lift Ship	36-39 knots	3000 Tons of Cargo in 250 Containers	Not Specified	Not Specified	5,000 tons; 3,000 tons in 250 Containers	None Yet Acquired
Wasp Class LHD	20+ knots	none given	844'	106'	40,500 tons at full load	
LHA (Replacement)	20+ knots	1,687 troops (plus 184 surge).	921'	116'	44,970 tons	Scheduled for Delivery in 2013
San Antonio Class LPD	22+ knots	personnel and vehicles only	684'	105'	25,000 tons	
ACS – Auxiliary Crane Ship	T-ACS 4-6 : 20 knots	none given	669'	76'	31,500 tons	
Marlin-class Heavy Lift Vessel	13.3 knots max (Blue Marlin) 14.5 (Black Marlin)	none given	736' 6"	137'	76,061 tons	
T-AKR LMSR	24 Knots	380,000 sq. ft. (Bob Hope class); 393,000 sq. ft. (Watson Class)	951'	106'	62,000 – 63,000 tons	
T-AK 3015/3016/3017 MPF(E)	17 – 24 Knots	3015:751 containers	3015: 754' // 3016: 864' // 3017: 885'	3015: 106' // 3016: 98' // 3017: 106'	48,000 – 54,000 tons	
Typical Ocean-Going Barge	N/A	varies with type of barge	310'	76'	9,000 tons	

CBIRF Team

In addition to physical modules based on TEUs, the platform/transport vessel will leverage capabilities of specially trained and equipped teams from a variety of agencies. These teams could be called up to staff the mission depending on the situation and the TEU modules being employed.

Because the U.S. Marines Corps' Chemical Biological Incident Response Force (CBIRF) is "trained to go into contaminated areas to rescue and stabilize victims exposed to dangerous airborne agents,"⁴⁹ they will be used specifically for the fast vessel response portion of Phase II. CBIRF has been used and/or they have exercised in many important cleanups in the past few years. For example, they collected anthrax bacteria samples at the Senate Offices during the October 2001 anthrax event on Capitol Hill.⁵⁰ They also

⁴⁹ Dalke, Kate. *Life Inside a Hazardous Materials Suit*. Medill News Service. Accessed on December 21, 2007 via <http://www.medillnewsdc.com/hazmatsuit.shtml>.

⁵⁰ Ibid.

worked alongside fire and hazardous materials teams during an exercise following the 1996 Summer Olympics pipe bomb explosion in the Olympic Village in Atlanta.⁵¹

CBIRF is an organized, self-contained and self-sufficient unit that trains extensively for biological and chemical terrorist attacks. They are flexible, and are known for their quick, prepared, and precise response during events and are capable of rapid response deployment anywhere in the world. These traits not only make them ideal to handle the second portion of Phase II, but also to be the main entity to oversee the thorough decontamination during Phase III of the response.

Normally CBIRF members are first responders, thus recovery in Phase III should be handled primarily by private decontamination and cleanup contractors. However, given the sensitive location of the attack on a U.S. vessel, a CBIRF team should remain after Phase II to direct and oversee the contractor recovery effort in Phase III. It will be important not to tie up the entire CBIRF unit, and only use those necessary to oversee, manage, and coordinate the cleanup during Phase III. Private contractors could be especially beneficial during a long-term recovery effort, for example those lasting a month or more. The use of contractors will allow a CBIRF team to oversee, manage, and coordinate a large-scale cleanup during Phase III.

During the Capitol Hill anthrax event, the Environmental Protection Agency (EPA) oversaw 27 contractors and three government agencies who conducted the clean up. These contractors were either removal, technical, supplies, or laboratory contractors and were utilized under EPA's existing competitive Superfund contracts or additional non-competitive contracts that were designed during and for the additional help needed during the anthrax event.⁵² In a similar fashion, CBIRF could use these types of contractors to assist with a large scale cleanup event onboard an oceangoing vessel at sea.

SECTION II. TEUs and Modular Response

“To address more effectively many security challenges, the Department is continuing to shift its emphasis from Department-centric approaches toward interagency solutions. Cooperation across the Federal Government begins in the field with the development of shared perspectives and a better understanding of each agency’s role, missions and capabilities. This will complement better understanding and closer cooperation in Washington, and will extend to execution of complex operations.”

- Quadrennial Defense Review, 2006, pp. 84-85.

⁵¹ Chemical/Biological Incident Response Force (CBIRF). Global Security.org. Page last modified: April 26, 2005. Accessed on December 21, 2007 via <http://www.globalsecurity.org/military/agency/usmc/cbirf.htm>.

⁵² Capitol Hill Anthrax Incident, EPA's Cleanup Was Successful; Opportunities Exist to Enhance Contract Oversight. GAO-03-686. GAO. June 2003: 13-19.

Overview

These containerized units are specifically designed to meet any contingency. Through a mix of new and existing capabilities, qualified personnel from DoD and myriad agencies can conduct operations rapidly and effectively using only the assets available in these units.

A set of laboratory equipment can be used to decontaminate personnel, sensitive shipboard electronics, general equipment and ship surfaces and internal systems. Isolation chambers will store contaminants and wastewater for safe transport and disposal. Habitability and Advanced Life Support (ALS) modules add additional life supporting space that could also be a part of this complement. Basic Life Support spaces augment organic first aid capabilities. Office modules provide the meeting spaces for DOD, Department of Justice (DOJ), DHHS, Department of Homeland Security (DHS), Center for Disease Control and Prevention (CDC), EPA staff, etc., to work together effectively.

Within the TEU network, a series of corridor modules provide infrastructure connections. Ruggedized external I/O points ensure that utility assets can connect. Additional details on specific TEU load-outs can be found in “Load-out Scenarios” and also in Appendix 4.

TEU Personnel

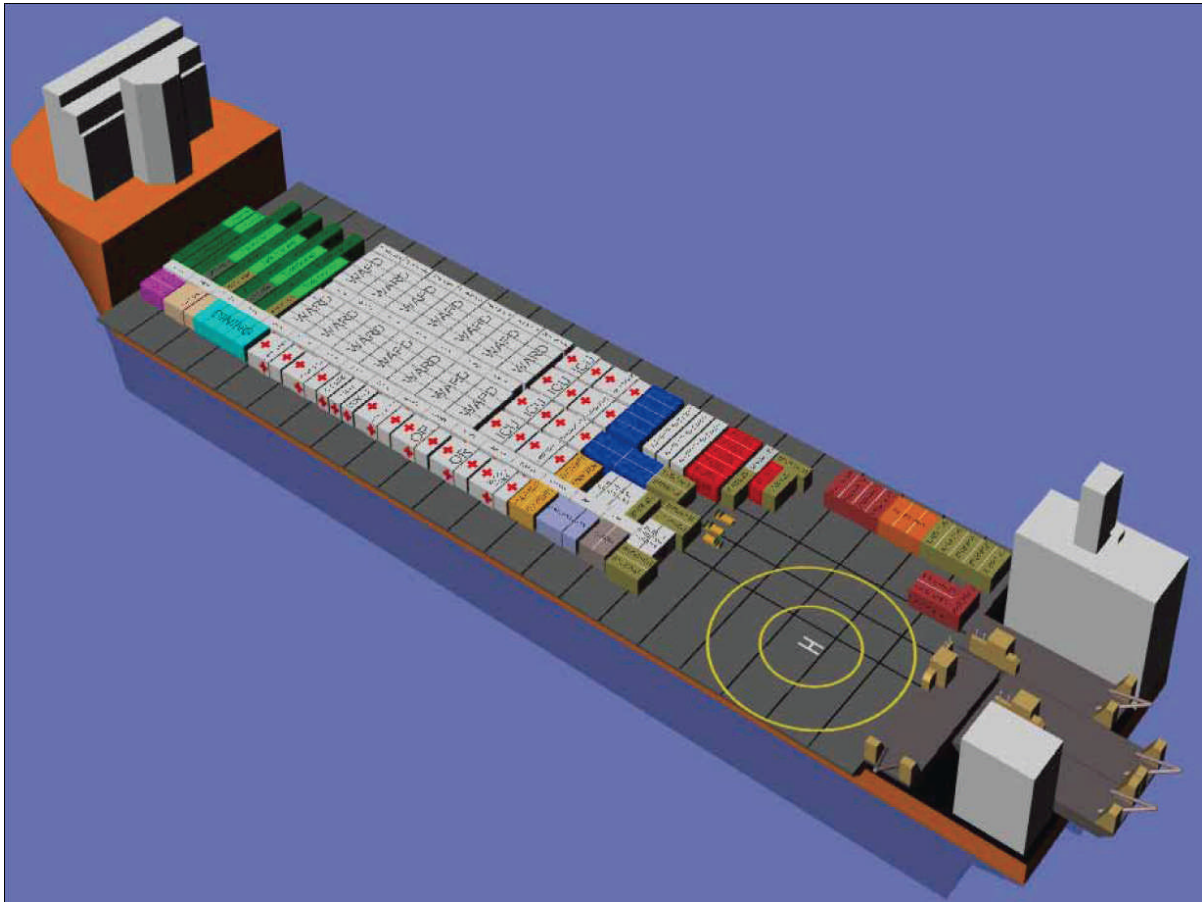
In addition to physical modules based on TEUs, the platform/transport vessel will leverage capabilities of specially trained and equipped teams from a variety of agencies. The personnel accompaniment will include various Navy and Marine Corps components as well as civilian personnel from a variety of governmental agencies, including the Federal Bureau of Investigation (FBI), Central Intelligence Agency (CIA), CDC, EPA and the Food and Drug Administration (FDA). These agencies will contribute their particular expertise, research, and unique abilities to the operation in order to accelerate cleanup and increase understanding of the situation. Civilian participation will necessitate using the already-existing Navy SOP to collapse personnel into the chain of command. The Phase III forces will join other officers and enlisted personnel on scene at the end of Phase II.

Benefits of TEUs and Modular Response

Flexible and Customized Response

The components of a full decontamination platform/transport vessel will be modularized in order to maximize the project’s flexibility and reach. The modular approach gives the CBRN team the ability to quickly assemble a completely customized response. On the resulting decontamination platform, everything is interconnected and each piece is essential. The platform’s footprint and resource use will be kept to a minimum. Another advantage of this model is that it does not require new deliverable technology. It is based entirely on preexisting technology and materials. TEUs are relatively inexpensive and easy to obtain and they require only minor adjustments to make them livable. The end result, therefore, is a completely mission-customizable, interchangeable system of

laboratories, living quarters, and other necessities for any possible decontamination operations.



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Figure 1: TEU arrangement for a mobile hospital onboard a HLS. This shows the potential for flexibility and customization of a system.

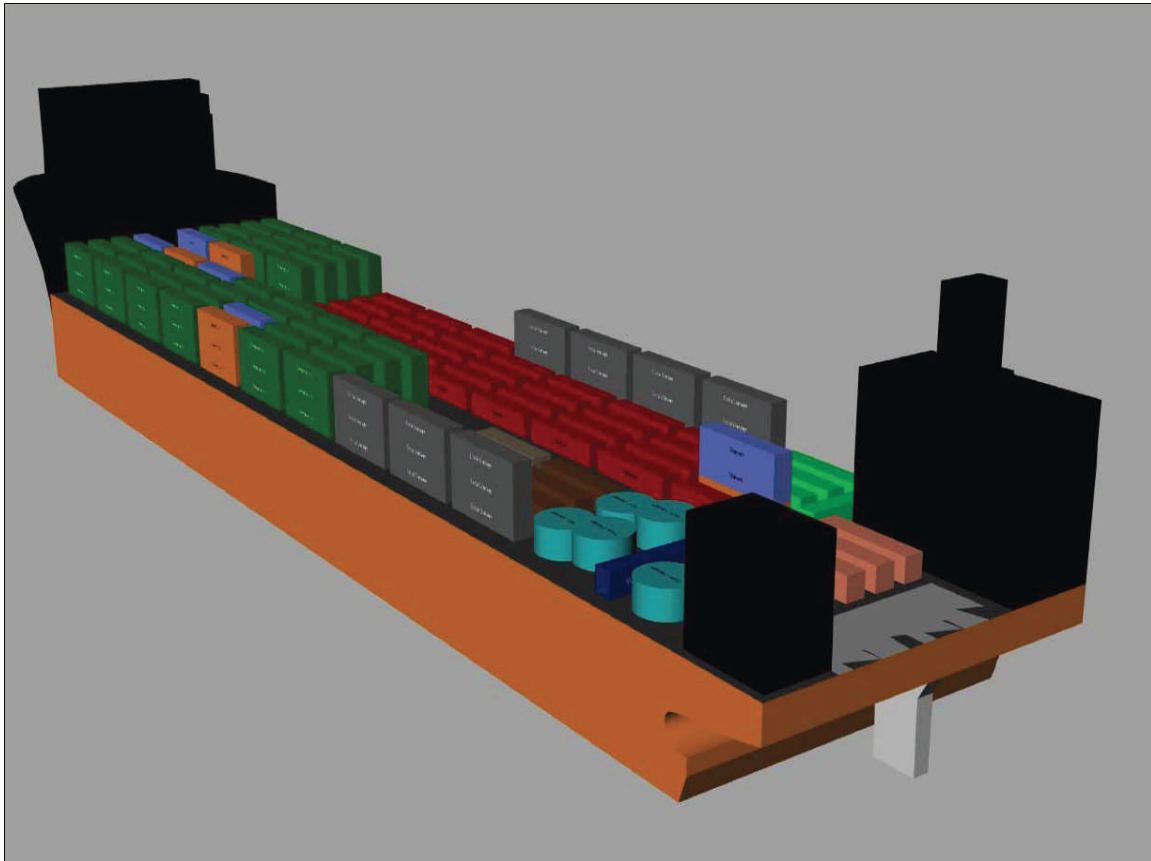
Safety

The basic premise is that every component of the response mission, from living quarters to laboratories to waste collection, will be packaged in an individual TEU that can be arranged on the deck of the ship. Corridor TEUs will connect all of these 'rooms'. The specially-designed TEU corridors will link laboratories, offices, storage space and living quarters, resulting in a completely self-contained living space that requires no input or connection with the transport ship. With the TEU corridor design, at no point should any personnel be on the deck of the ship unless they are wearing HAZMAT gear. There will be anterooms stationed at every entrance to the deck of the ship, allowing personnel to safely remove HAZMAT suits and to decontaminate before entering the larger network of TEUs. At every entrance, there will also be portable detection devices, customized to the mission, to ensure that personnel remain uncontaminated. Additionally the connected

⁵³ Illustration is used with permission from Naval Surface Warfare Center Carderock Division/ Center for Innovation in Ship Design (NSWCCD CISD).

TEU modules will be sealed and over pressurized to further limit the possibility of contamination.

Within each TEU, spec papers will cover all aspects with a reasonable level of detail, while allowing the contents of each module to be adjusted as needed on a mission-by-mission basis. The most technical aspects, such as the exact lab equipment used, can be stated with rough parameters now and more rigorously researched as the project moves forward.



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Figure 2: This image demonstrates a layout with stacked TEUs, a possibility for decreasing the footprint and increasing the potential range of ship sizes for the transport vessel.

Cost Effective

Price is an additional factor in planning the TEU village. Shipping containers are readily available at prices below US\$6,000 per unit, and would require only additional sealing and environmental controls to transform them into a module for the decontamination platform. In this 'plug-n-play' model, longshoremen can quickly arrange the TEUs to fit pre-designed maps customized to the type of CBRN event to which the ship is responding. It will take minimal time and manpower to prepare one of the TEU 'villages' for deployment, and no new deliverable technology is required for the project.

⁵⁴ Illustration is used with permission from Naval Surface Warfare Center Carderock Division/ Center for Innovation in Ship Design (NSWCCD CISD).

The small, self-contained network can facilitate coordination of different laboratories and offices, as well as the various agencies that may be represented on the ship. There will be a clear path to disseminate and share information among the onshore Operations Center, the bridge of the ship, and the various departments and modules making up the mission.

Ease of Communication

The on-ship intranet will also facilitate communication of findings and updates on the decontamination process, and every member of the ship will have reachback capabilities through easy contact with onshore personnel, either through the Operations Center, if they are Navy personnel, or through their departments, if they are non-Navy Personnel.

With its easy networking capabilities and its inexpensive creation and maintenance, a modular TEU-based system facilitates a well-orchestrated decontamination operation, allowing personnel at all levels to stay in contact, around the clock, with one another as well as with the operations center, which has reachback capabilities. Because the system is built around standard-sized, existing technology, any shipyard can store TEUs, transfer them to the ship and, using pre-designed maps, assemble a decontamination village. Because the network is completely self-sufficient, with TEUs handling wastewater, electricity and potable water, space only becomes a factor when choosing the platform/transport vessel to move the decontamination ops to the CBRN event location.

Equipment

The equipment space will act as the connector. The four nodes will contain all the systems necessary to operate any individual Naval vessel, and these systems complement each other with minimal overlap. These systems will connect and interoperate with other TEUs through networked systems architecture as well as through internal communications.

Each TEU within this system will be powered off of the vessels main power source with redundancy systems contained within the cluster. Because of the sensitive equipment and specialized environment necessary to operate the systems contained within this cluster, no water access will be required or installed. The baseline container will be a 20' heavy test TEU. Further customization to the container will include:

- Insulated floor, walls and ceiling to prevent interference from outside sources;
- Raised floors consistent with those typically used in Top Secret (TS) environs;
- Specialized lighting necessary for optimal performance of personnel and equipment;
- Equipment bracing to prevent shifting during maneuvers and in high sea states;
- Container airlocks preventing contamination by outside variables;
- Anterooms outside of sensitive areas to prevent contamination, enhance security and maintain integrity of sensitive areas;
- Keycard access;
- Tracking beacons in the event that a container is lost at sea.

Environmental Considerations

These TEUs will be especially sensitive to external contaminants. A number of environmental considerations will be built into the structure of these TEUs including passive protection from external electromagnetics through insulation and anterooms that will limit the introduction of external contamination from environmental variables (sea water, dust, etc). Airlocks for these containers will also allow for their recovery should adverse conditions affect the vessel (catastrophic loss of vessel, container tie down failure, etc) enabling these containers to remain buoyant, even when fully loaded, until recovery.

Post-ops, the TEUs will need to be decontaminated. This can be accomplished on-ship with preexisting methods and materials used for tank decontamination.

In addition to the TEUs themselves, the waste products from the decontamination process will have to be safely disposed of. All ports in the United States allow properly-stored hazardous waste, with a permit from the US Coast Guard (USCG). Once returned to port, the inert waste can be disposed of properly. There are a large number of waste disposal companies in the Philadelphia area. The major companies are:

- Environmental Control Systems Inc. - Broomall, PA
- Envirosource Inc. - Horsham, PA
- Solid Waste Services Inc. - Audubon, PA
- Mxi Inc. - Langhorne, PA
- Jack Robinson Waste Disposal Service - Bellmawr, NJ

TEU Design, Production and Maintenance

The fabrication of the TEUs used on the platform/transport vessel will take place over three major phases. The initial concepts for each TEU, which are laid out in the completed specification documents included in Appendix 4, will be combined with any additional research and planning necessary before a physical prototype is constructed. From this prototype, testing and adjustments will be made to result in the final designated TEUs, which will then be manufactured in the relatively small required quantities. (Because some designs will need more reproductions than others, e.g., living quarters, corridors, the manufacturing process should be scalable.) Finally, post-mission, the TEUs will need to be restocked, repaired, and have any additional maintenance completed before their return to storage.

Although the TEUs have gone through a top level conceptual design, major research will still be required to complete the design of some of the containers, specifically those tasked as laboratories. Additional research and planning may be needed to quantify the specific methods to cover and seal the TEUs against potential environmental contaminants while maintaining a hospitable environment within them. Engineering and pharmaceutical/HAZMAT knowledge will be required to complete this portion of the design process.

Once the prototypes are completed and approved, the manufacturing phase will begin. A warehouse will be needed, with attached offices for a pool of engineers. These personnel

will produce blueprints based on the prototypes already created, and from that basis the actual TEUs will be fabricated and/or modified. Access to various transport methods will likely be required, with the TEUs moving via air, rail and road at different points of their fabrication and use.

This is not envisioned as a large-scale manufacturing project, although the manufacture of even limited numbers of TEUs will create short-term jobs requiring a trained workforce at a manufacturing base. Multiples of most of the planned TEU prototypes will need to be made, to account for the maximum flexibility of the mission. During manufacture, each TEU should be tagged with a unique Radio Frequency Identification (RFID) tag to aid in later maintenance.

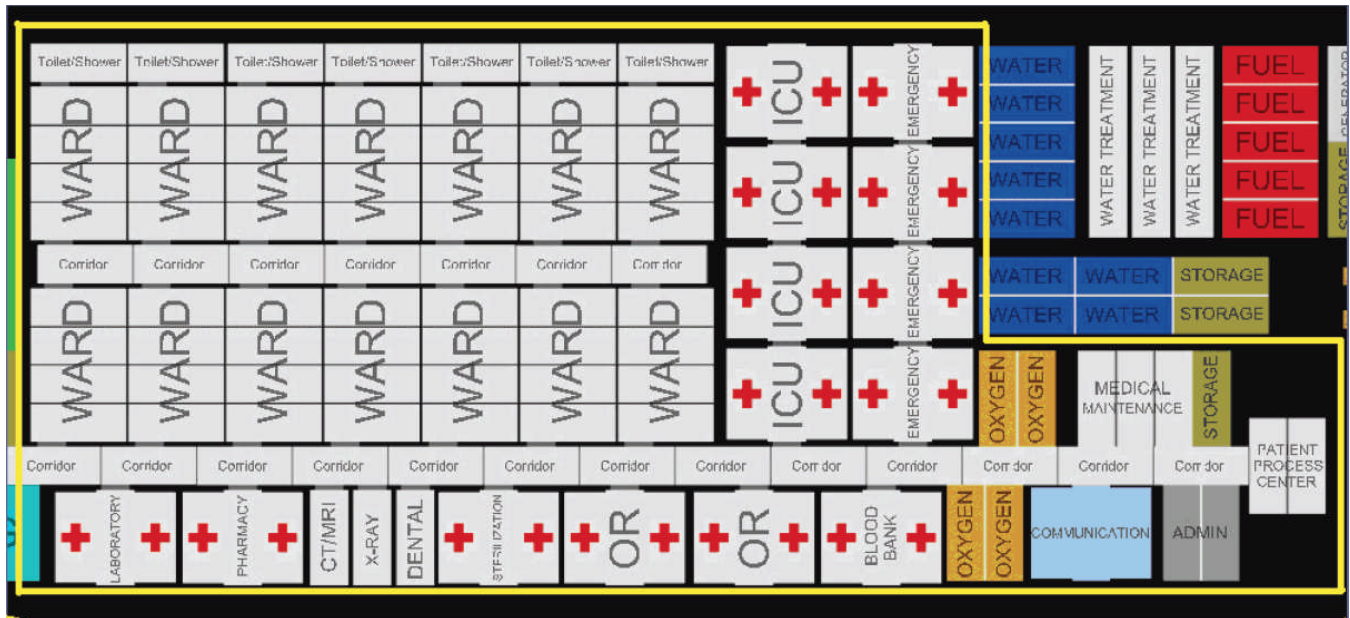
After a completed mission, TEUs should be decontaminated while still on the transport vessel, and then returned to the manufacturing base on an as-needed basis. There, based on the data linked to the RFID tag, any necessary repair may take place, as well as any design changes that are required. Finally, the container can be restocked and returned to its storage warehouse in preparation for the next decontamination ops.

There will be some specific needs in the manufacturing and maintenance location. Experience with maritime issues is necessary, as well as the equipment to manufacture and move the specialized TEUs. A pool of engineers to produce blueprints and test the TEU prototypes will be needed for the duration of the design and production parts of this project, and a trained workforce will be needed to produce them as well as maintain TEUs after their return from completed missions.

Table 6: TEU Action Timeline

	TIMELINE ACTION	RESPONSIBILITY
1	Develop concept for each TEU type (laboratory, hospital, wastes/hazmat, office, housing, etc.) designed through research and planning including covering & sealing TEUs against potential environmental contaminants	Research Cluster/TEU Facility
	↓	
2	Construct physical prototype	TEU Facility
	↓	
3	Test and make adjustments to prototype	Research Cluster/TEU Facility
	↓	
4	Design final TEU per TEU type	TEU Facility
	↓	
5	Manufacture designed TEUs in necessary quantities	TEU Facility
	↓	
6	Perform maintenance on all TEUs twice yearly in storage	TEU Facility
	↓	
7	Design specific TEUs based on the strategic environment and potential threats/adversary capabilities and/or if an attack occurs	Research Cluster
	↓	
8	If utilized, decontaminate TEUs while on transport vessel prior to being returned to Port	CBIRF and/or contractors
	↓	
9	If utilized, post mission TEUs restocked, repaired and maintenance completed before their return to storage	TEU Facility

Load-out Scenarios



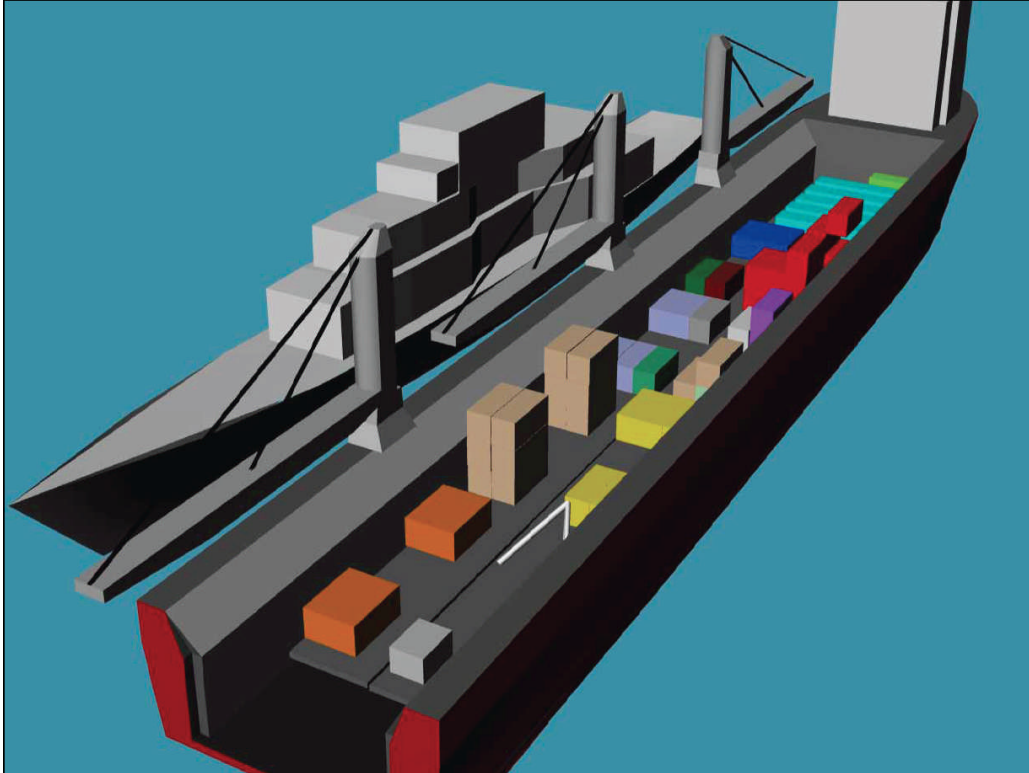
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Figure 3: Example load-out scenario for a mobile, TEU-based hospital.

Due to the vast variety of crew accompaniments fleet-wide, as well as the wide range of commercial vessels that the Navy may be called on to assist, it is impossible to estimate the number of TEU units needed for a “typical” response. There are however some reasonable assumptions and each Phase III response personnel accompaniment will likely have as a baseline:

- CDC/FBI (8)
- ChemBio Equip Decon, if necessary (10)
- Waste/HAZMAT (50)
- General Office (4)
- Sensitive Equipment Decon (5)
- Toxic Diving (1)
- Robotics (1)
- FBI, if necessary (1)

⁵⁵ Illustration is used with permission from Naval Surface Warfare Center Carderock Division/ Center for Innovation in Ship Design (NSWCCD CISC).



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Figure 4: Ship layout that may closely approach a decontaminated vessel.

Smooth coordination of interagency operations will be particularly important during these contingencies. This will only be achievable through a robust training and exercise program that drills this capability on a regular basis. The chain of command must be maintained in this type of complex situation, i.e., a CBRN event. All those aboard will fall under the Commanding Officer (CO) because this is a Navy operation. Ultimately, the CO will have the final say about the conclusion of operations and the parameters of safe operation. The CO will directly oversee the site and is in charge of ensuring the safety of all members of the team regardless of their agency affiliation.

In terms of the chain of command, all members of decontamination teams (Center for Disease Control (CDC) and EPA elements) should be treated as enlisted personnel and will coordinate with the NCOs and officers of the decontamination element. Any Field Agents involved will report directly to the CO because the evidence they collect and conclusions they draw will probably be highly classified.

Daily SitReps will require a coordinated and cooperative effort among the lead officers of each specialty area, the Executive Officer (XO) and the CO to ensure the most appropriate conclusion of operations. Daily SitReps between the scene and the Pentagon will also ensure continuity between the operation and the DOD. Interagency cooperation

⁵⁶ Illustration is used with permission from Naval Surface Warfare Center Carderock Division/ Center for Innovation in Ship Design (NSWCCD CISD).

at the higher levels has traditionally been difficult, and it is likely that this will continue to be an issue. Therefore, on-site intra-agency cooperation is essential.

Conclusion of Operations

The Situation Commander will determine when to conclude operations. The only external minimum requirement is a determination that the vessel is either combat-ready or that it cannot be decontaminated at sea. Decontamination standards will have been evaluated and established during Deuce Alpha Phase II, generally by consensus of stakeholders. These standards will set an evaluative framework within which the mission will occur.

Command, Control, Communications, Computers, and Intelligence/Information Office (C⁴I/IO)

The complexities of decontamination operations at sea are innumerable – a multitude of agencies, personnel and materials in constant motion all while under threat. Maintaining command over such a complex operating environment is difficult but necessary and will be performed through a complement of TEUs that will combine to create the Command, Control, Communications, Computers, and Intelligence/Information Office (C⁴I/IO).

This cluster will collapse the multiple layers of the decontamination process – detection, protection, treatment, clean-up, investigation, etc – into a single integrated picture for the Commander, enabling him to coordinate responses, protect the Fleet and operate efficiently. In the C⁴I/IO, all information available through all other TEUs will be integrated with additional information from throughout the Fleet, creating a seamless view of the battle space. This cluster will be extremely adaptable and allow for a multitude of delivery vessels, from civilian freighters to naval warships.

The C⁴I/IO is the lead Phase III component. Accompanied only by equipment necessary to sustain the Command team, this cluster is the first sea-bound, rapid deployable component of the response to be preceded by the airborne response and assessment team and followed by the full-up decontamination capability. The C⁴I/IO cluster allows the Fleet to shift Command and Control from the Carrier Battle Group (CVBG) Commander to a dedicated Situation Commander who will oversee the remainder of the response before turning the ship back over to the Combatant Command.

The C⁴I/IO is the nerve center for operations and logistics and is comprised of 5 modular nodes: (1) NetCentrics and Comm's; (2) On-Vessel Tracking Data; (3) Fleetwide Intelligence, Surveillance and Reconnaissance (ISR); (4) Fire Control Center; (5) Logistics.

Upon arrival, the C⁴I/IO Commander will assume command over the scene. He will first be briefed on the incident. As the nerve center for the operation, the C⁴I/IO will control and monitor operations during the decontamination, determining which assets are appropriate for a given task and the priority in which those tasks will be performed. The Commander will control all assets and personnel regardless of agency or affiliation unless otherwise dictated by the SecDef or Combatant Command. Outside investigative

agencies (FBI et al.) are responsible to the Commander as well as through their usual chains of command with final say over safety matters going to the vessel Commander.

Aboard host vessels not organically equipped with the fleetwide ISR and Fire Control systems, the C⁴I/O will also integrate fleetwide intelligence on movements of friendly and enemy vessels, aircraft and personnel and maintain control over defensive systems. Due to the high level of automation with the Sea Launched Rolling Airframe Missile (SeaRAM) system, fire control is marginally intensive but remains vitally important.

The final and most important capability contained within the C⁴I/O cluster is the secure communication system that allows the various TEUs a direct reachback link to stateside support assets.

The C⁴I/O will fuse data from all other TEUs into a single reporting architecture that gives the Commander a single picture of the battle space as the information becomes available. From these reports, the Commander can determine the length of operations and coordinate the movement of any additional assets to the scene, casualty evacuation, contaminated vessel transit, and vessel and operational support vessels based upon intelligence gathered aboard the contaminated vessel and upon the analysis and recommendations of subordinate and support personnel. The Commander also makes decisions concerning the conclusion of operations.

The C⁴I/O gives the Commander all the assets he will need to prosecute operations and complete his mission.

Operations Center

Overview

The Operations Center will provide a 24/7/365 center to act as a contact point for the platform/transport vessel. At the same time, the Operations Center will direct the mission, acting as a communications line among the various phases and relevant government, military and civilian entities, and leveraging resources available to increase the success of the decontamination operation. Ideally, the Center should be the only entity a CO needs to contact in order to initiate the decontamination process. This efficient movement of information and personnel will increase the likelihood of a quick response to CBRN events. It will also establish a chain of command and set of procedures that may be used as needed, instead of the largely ad hoc nature of current responses.

Products

- Output of information- the Operations Center will gather and disseminate collected data from both the platform/transport vessel and related research efforts.
- Situational awareness, on ship and land, of all involved assets
- Define and articulate situation, steps needed for amelioration, and current status of contaminated ship

The Operations Center will primarily produce and communicate information about the state of the CBRN event and contaminated ship. The Center will have the staff and capability to gather data from the platform/transport vessel as well as relevant research and data from on-land resources, thus planning and executing a more efficient, informed decontamination process.

The Center will also act as the lynchpin of the decontamination process, maintaining situational awareness both on ship and on land, leveraging its unique position as the entity in constant contact with personnel from all involved entities. Finally, the Center can also use its unique position to articulate the general situation, the specifics of the decontamination mission and the status of the contaminated ship.

Functions

- Act as an intermediary between Navy/vessel and others
- Link on scene responders, Federal agencies, educational institutions and private sector research

The Center will have the capability to facilitate contact among the affected vessel(s) and relevant expert entities. Standing participants will include:

- Navy
- Other branches of DOD
- Other Governmental departments and agencies judged appropriate
- Watchstanders

Operations Center personnel may belong to one of three groups, depending upon their position: staff, watchstanders and consultants. Staff will consist primarily of Navy officers and ratings in a variety of support and communication positions. They will maintain situational awareness at all levels, and monitor the joint efforts of decontamination, clarifying and articulating the desired outcome in order to best use the specific strengths of the cross-section of civilian, government, and military participants.

Watchstanders will consist of personnel from non-Navy participating entities acting as liaisons between the decontamination efforts and their agencies. They will primarily come from DHS and HHS agencies, but other entities may become involved as well. Watchstanders are often present in multiple DHS operations centers, although historically their role has not been so well-defined. Within the decontamination Operations Center, watchstanders will specifically maintain situational awareness, thus increasing their ability to respond quickly when their agency needs knowledge and/or manpower.

The Operations Center will be completely integrated with the entire decontamination process. They will be an information hub, reachable through the on-ship intranet to quickly access knowledge and analysis of findings. Lines of communication with the platform/transport vessel will remain open at all times, allowing a quick transfer of information between the Operations Center and the bridge of the ship. Communication will occur solely among Navy personnel, with necessary information being disseminated

to non-Navy personnel on a need-to-know basis. Adaptations of this model will be accommodated when necessary.

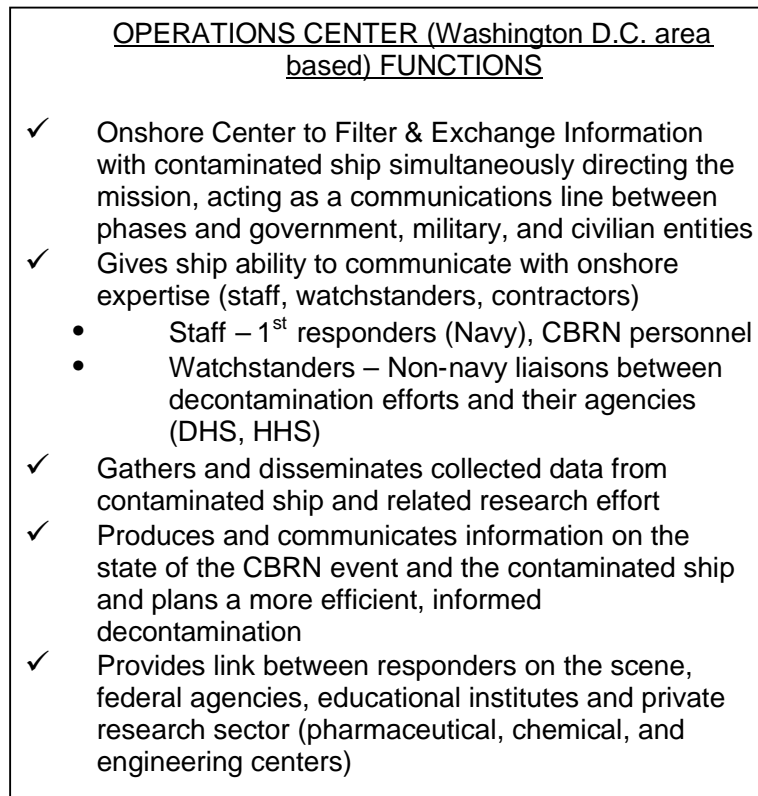


Figure 5: Operations Center Functions

Enlisted Personnel

ET - Electronics Technician (Advanced Electronics Computer Field).

ETs maintain and repair electronics equipment such as radar, communication and navigation equipment.

IC - Interior Communicationman (Advanced Technical Field).

IC duties include: maintaining and repairing interior communications systems; preparing and interpreting blueprints, wiring diagrams and sketches; installing and inspecting dry cell and storage batteries; recharging wet cell batteries; testing interior communications and gyrocompass equipment; installing telephone and other communications circuits, boxes, switchboards and bell buzzer systems; maintaining and operating TV systems; maintaining and repairing shipboard navigation equipment.

IS - Intel Specialist.

IS duties include: analyzing intelligence information; identifying and producing intelligence from raw information; assembling and analyzing multisource operational intelligence; preparing and presenting intelligence briefings; plotting imagery data using maps and charts; providing input to and receive data from computerized intelligence systems ashore and afloat; maintaining intelligence libraries and files.

IT - Information System Technician.

IT duties include: designing, installing, operating and maintaining state-of-the-art information systems technology including local and wide area networks, mainframe, mini and microcomputer systems and associated peripheral devices; writing programs to handle the collection, manipulation and distribution of data for a wide variety of applications and requirements; performing the functions of a computer system analyst; operating and coordinating telecommunications systems including automated networks and the full spectrum of data links and circuits; transmitting, receiving, operating, monitoring, controlling and processing all forms of telecommunications through various transmission media including global networks; applying diagnostic, corrective and recovery techniques to all facets of the integrated information systems; maintaining all necessary logs, files and publications at the communications center.

Officers

IO - Intel Officer.

SWO - Surface Warfare Officer.

Netcentrics and Comms

AN/USQ-119E(V) - GCCS-M Afloat Node

The Global Command and Control System - Maritime (GCCS-M) provides all Maritime Commanders with a single, integrated, scalable command, control, communication, computers, and intelligence (C⁴I) system that processes, correlates, and displays geographic track information on friendly, hostile and neutral land, sea and air forces, integrated with available intelligence and environmental information, to support command decision making. The Afloat variant provides a single C⁴I capability to sea-based forces.

GCCS-M fields a baseline system consisting of core functionalities and a set of mission-specific subsystems. Additional subsystems, as well as core upgrades and new functionality, will be fielded in future releases allowing GCCS-M to evolve as warfighter requirements change with incremental implementation of hardware and software releases.

GCCS-M will utilize super-high frequency (SHF), ultrahigh frequency (UHF), and extremely high frequency (EHF) satellite communications (SATCOM) for secure communications and the Navy Multi-band Terminal SECRET Internet Protocol Router Network (SIPRNET), Non-Secure Internet Protocol Router Network (NIPRNET), and JWICS (Joint Worldwide Intelligence Communication System).

International Maritime Satellite (INMARSAT) access will serve as back-up non-essential bandwidth.

On-Vessel Tracking Data

Active RFID

Radio Frequency Identification has been employed by DOD since the early-1990s. RFID tags will provide control and track equipment and inventory. Active RFID tags utilize an onboard power supply to transmit at higher power levels than passive tags, allowing them to be more effective in "RF challenged" environments like shipping containers. Active tags typically have a 1500' range and a battery life of up to 10 years. They also experience fewer failures and errors than other tags or human tracking. Active tags are also beneficial to monitor a number of additional dynamics including temperature, humidity, atmospherics, radiation, etc. The central reporting and control center would be housed within this tracking center.

FBCB2 – Force XXI Battle Command Brigade and Below

FBCB2, commonly known as *Blue Force Tracking*, gives the Command and Control center an integrated picture of the battlespace. For this contingency it provides for accountability of all members of the decontamination team. Blue Force will tell the C⁴I/O where every member of the team is at all times.

JTIDS/TADIL J/LINK 16, TADIL A/LINK 11, TADIL C/LINK 4A, TADIL/LINK 14

These data links provide real-time or near real-time ISR data to be passed from other vessels, aircraft and systems utilized in the battlespace, enabling the commander to make choices on ship survivability and maintain situational awareness.

TAC-4 Datalink Processing Systems

Pieces of the TAC-4 system will process signals and bring down data off the network to be processed by analysts or consumed by commanding officers, providing a complete picture of the battle space.

MK-15 Mod 31 SeaRAM Fire Control System

The SeaRAM system provides the latest in survivability armament by combining the sensor and tracking systems of the MK-15 Phalanx Close-In Weapon System (CIWS) with the Rolling Airframe Missile (RAM) system. SeaRAM is capable of countering a broad array of threats including anti-ship cruise missiles, surface craft, helicopters, unmanned aerial vehicles (UAVs) and fixed wing aircraft using a self-contained 11-missile kinetic weapon assembly. The Ku-band search-and-track radar and a new Forward-Looking Infrared (FLIR) imaging system are borrowed from the Phalanx. The RAM battery can put each 9' round downrange above Mach-1 with a 20lb blast fragmentation warhead. This system is also unique to the Fleet because of its indigenous Fire Control system. The Fire Control officers, a SWO element, would be housed in this node.

Existing Operation Centers

A review of current Operations Centers managed by DHS and DOD suggests that these new activities may be rolled into one of the existing centers. To facilitate contact, DHS and DOD stakeholders would select the most appropriate Operations Center, preferably located in the National Capital region. The expanded Operations Center and the Philadelphia Center would establish a close working relationship, with regular staff rotations, close consultation, and conferences.

Pre-Positioning Phased Roll-Out

The biggest challenge is to ensure that the system will get to the contingency as quickly as possible in order to carry out its mission. We remedy what would be a long supply chain by extending the capability through co-location at Pre-Positioning or Pre-Positioned stocks. The deployment of our equipment to Pre-Positioning, however, will likely not be immediate. This document will outline the Pre-Positioning system and establish a phased roll-out to key Pre-Positioning globally allowing for the establishment of a global-reach response capability over an 8 to 10 year spiral beginning with the first unit in Philadelphia.

Pre-Positioning

The U.S. military stockpiles or prepositions reserve military equipment and supplies near potential conflict areas to ensure that the material is quickly available to forces in the event of a contingency. During a contingency, Pre-Positioning accelerates response times so that only the response forces and a relatively small amount of materiel need to be flown in to the contingency area. As a result, DOD can field heavily-equipped, combat-ready forces in hours and days rather than the weeks and months.

The Army and Marine Corps rely heavily on Pre-Positioning. The Air Force and Navy have relatively small programs, because they tend to deploy with most required equipment. USN/USMC programs include:

- 1) The 16-ship Maritime Prepositioning Force;
- 2) A brigade of equipment in Norway, and;
- 3) Other items, including hospitals, ordnance and a small amount of other material.

Maritime Prepositioning Force

The top priority in the Marine Corps and the Navy Pre-Positioning programs is the Maritime Prepositioning Force. This force consists of 16 Military Sealift Command (MSC) Prepositioning ships especially configured to transport supplies for the USMC. The ships were built or modified beginning in the mid-1980s and are forward-deployed in three squadrons to regions around the world. The ships contain nearly everything the Marines need for initial military operations including tanks, personnel carriers, ammunition, food, fuel, spare parts, etc. The force also contains Navy equipment, including construction equipment and crafts used for off-loading and ferrying equipment and supplies ashore.

The three squadrons – MPS Squadron One, located in the Mediterranean Sea and eastern Atlantic, MPS Squadron Two, located at Diego Garcia, and MPS Squadron Three,

located in the Guam/Saipan area – each carry sufficient equipment and supplies to sustain about 15,000 marine air-ground task force (MAGTF) personnel for up to 30 days. Any of the 16 ships is designed to discharge cargo either pier-side or while anchored offshore using an assortment of lighterage (small craft designed to transport cargo or personnel from ship to shore) carried aboard.⁵⁷

Project Targeted Pre-Positioning Locations

There will be four planned pre-positioned locations throughout the world. Each unit will be identical in every way, enabling the specialized force to rapidly respond to any contingency in any Area of Responsibility (AOR). The chosen locations will provide the best access for stateside reach-back and re-supply while also being forward deployed to hotspots where this function will be most useful. All targeted locations other than Philadelphia house land-based and afloat Pre-Po stocks and are the largest within the DOD Pre-Po system

Philadelphia - As the project base point and home to the Manufacturing Maintenance and Research and Development (R&D) Center, Philadelphia will provide the best test bed for the first deployable unit. Philadelphia is ideally suited for security, transportation access, available land, skilled and unskilled labor, room for growth and is a center of excellence for technology, pharmaceuticals and medical research developments. From a Defense standpoint, the first unit should be housed away from the main Fleet in Norfolk to prevent having a single point of failure, but it should be within short range of that Fleet in the event of a contingency. The Philadelphia Naval Ship Yard (PNSY) is also ideal because it is isolated from collateral targets. Finally given the proximity to the system's proposed manufacturing base will expedite rapid replacement of parts and materials.

Diego Garcia - Diego Garcia is an essential PREPO point for missions stretching from Africa through the Philippines and beyond. It is a primary waypoint between the Pacific and Atlantic and it has a direct support mission for Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). Remote and isolated, Diego Garcia has enough runway space to accommodate any aircraft carrying any load and has substantial offset for afloat PREPO stocks. Because this site is so remote, security is somewhat less of a challenge. A main advantage of the location is the ability to rapidly mobilize from Diego Garcia to any point within the Indian Ocean in hours.

Mediterranean Sea - The Mediterranean region is the centerpiece of our strike portfolio. From this region, it is possible to monitor activities on three continents. Our PREPO in the Mediterranean are required to extend our reach into the Middle East and North Africa as well as to support of operations in the Balkans. The Med PREPO could respond both to the immediate threats in the eastern Mediterranean and to contingencies along the Atlantic seaboard of Europe and Africa. It also has the capacity, together with the Diego

⁵⁷ Information culled from two primary sources:

(1) United States Navy Military Sealift Command – Maritime Prepositioning Force, <http://www.msc.navy.mil/pm3/mpf.asp>, and;
(2) General Accounting Office, *Military Prepositioning: Army and Air Force Programs Need to be Reassessed*,
GAO/NSIAD-99-6 (Washington, DC: U.S. GAO, 16 November 1998), Appendix I - Page 60.

Garcia PREPO, to provide a robust response capability to multiple simultaneous contingencies in-theater.

Guam/Saipan - This node will be the main support provider for PACOM. As discussed in the prior San Diego section, this node will probably be relocated to the Guam/Saipan PREPO after a brief stint on the West Coast of the Continental United States (CONUS). Guam/Saipan will be able to respond easily to contingencies revolving around United States Forces Korea (USFK), China, as an SSN response force for Pearl Harbor, and in conjunction with the Diego Garcia PREPO in the Philippines, Indonesia, etc.



Figure 6: This chart shows the non-CONUS Pre-Po's.⁵⁸

⁵⁸ Developed from Figure 1, Page 9 in GAO/NSIAD-99-6 (Washington, DC: U.S. GAO, 16 November 1998)

Roll-Out

The roll-out schedule, which is prescribed more specifically in later sections, will permit the Navy to spread the costs of system development and procurement over several years and capitalize on lessons learned between now and deployment.

Schedule

The roll-out of the Philadelphia node will be the longest and most involved. The total build-out period will likely take several years due, in part, to the large amount of infrastructure involved within the PNSY footprint. The follow-on PREPO nodes, however, should follow rather rapidly with the longest delays being for year-to-year procurement. Total build-out should take between 8 and 10 years with the funding continuum remaining constant every other year with funds being expended over the course of 1.5 years.

Each TEU should proceed from the factory location, which, as proposed, is a Philadelphia-area manufacturer, by ground transit to their secondary mode of transit upon completion of that secondary mode's load-out requirements. For example, if nodes are to be deployed by Pre-Po vessel, all TEUs should ship from the final assembly within a single window whereas if the nodes were being deployed by strategic airlift assets, the convoy of fully assembled assets would be considerably smaller and would require multiple additional convoys to fully stock the PREPO. This chart shows the projected roll-out schedule beginning from 'zero-year' which is the year from which funding begins for the procurement of TEU systems for the PNSY node. Under this projected roll-out, capability is transferred from San Diego to the Guam-Saipan PREPO at Z-Year +8.

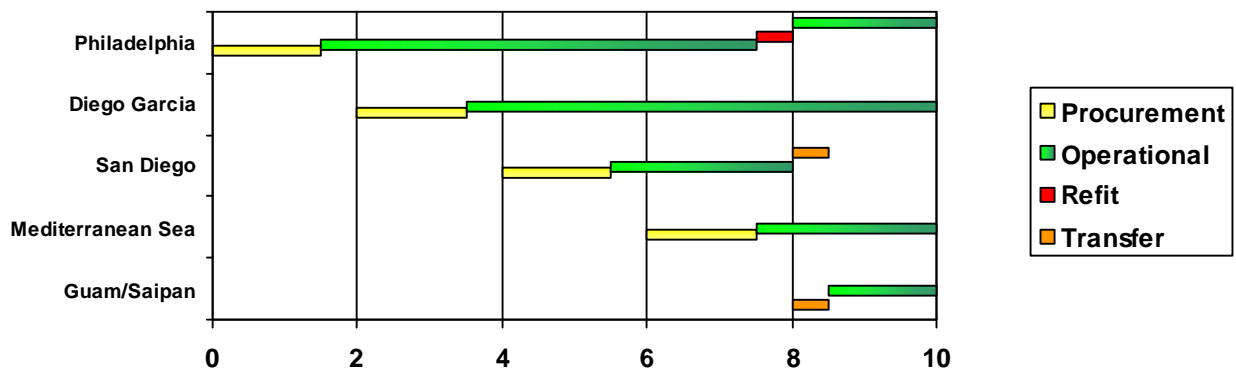


Figure 7: Projected TEU System Roll-Out Schedule

NOTE: All times are projected and rounded to the nearest half-year, therefore, the estimated length of time for transfer of the San Diego node to Saipan is estimated at six months. Obviously a number of variables can affect schedule. This chart takes into account some but not all of those factors and should be used as a rough guide rather than a scripted schedule.

The PNSY node, being the most intellectually rigorous and technically complex, will undoubtedly present significant challenges. For this reason, there is a six-month refit period structured into the build-out schedule to allow for updates of equipment and

incorporation of lessons learned from later spiraled nodes. One final detail of the roll-out schedule is that from Z-Year +5.5 there are always three active nodes on alert and available for rapid deployment.

Advantages of a Philadelphia Metropolitan Area Location in Response to Research and Manufacturing Needs

This project has geographical requirements from the design phase forward. It requires a port with ship access and a warehouse storage facility for the TEUs, preferably nearby. After the initial construction period, each shipping container will need to be stored, when not in use, and often repaired, overhauled and restocked upon its return from a mission. A port-side warehouse (or one within easy reach via air, train or road), will house the TEUs during construction and when not needed for a decontamination operation.

The strengths and weaknesses of various large ports around the United States should be evaluated when deciding where to base the research center and the TEU design, production, and maintenance facility. The port facility analysis, conducted by SRRI, evaluated the various port options based on their access to research, cost structure and threat potential. Table 7 (see below) shows that only five American port regions have the right combination of industries and labor forces for project success. These ports are New York City, Los Angeles, Philadelphia, Boston and San Francisco.

Table 7: Port Regions Cluster Analysis⁵⁹

Metro Area ⁶⁰	Bio & Pharma	Chemical Products	Transport & Logistics	Med. Devices	Education & Knowledge Creation	Analytic Inst.	Combined Cluster Ranking (lower numbers signify better rankings)*	Best Cluster Value (lower numbers signify higher value)
New York City, N. NJ LI	1	2	1	3	1	4	2.00	27.92
Los Angeles	3	7	2	1	3	1	2.83	41.11
Philadelphia	4	4	9	8	5	8	6.33	24.23
Boston	6	10	16	4	2	2	6.67	45.57
San Francisco	5	30	7	7	7	9	10.83	167.20
Miami	7	30	6	9	15	30	16.17	
Houston	30	1	8	30	16	30	19.17	
Baltimore	16	19	30	30	12	12	19.83	
Seattle	30	30	10	20	19	11	20.00	
Atlanta – Savannah	30	12	4	30	14	30	20.00	
DC & N. Virginia	30	30	15	30	4	15	20.67	
San Diego	30	30	30	11	10	13	20.67	
New Orleans	30	16	18	30	30	30	25.67	
Tampa	20	30	30	30	30	19	26.50	

There are several serious considerations that must be factored into these ratings of the potential port cities. The New York and Los Angeles/Long Beach port are both considered high value targets for terrorism by DHS. New York has been the site of two major terrorist actions in the last 15 years. In addition, both New York City and Los Angeles have maximized their cargo handling capacity and suffer space constraints in highly valued real estate markets. San Francisco's affordability index rating shows that the area has a very high cost of living. As an example, Google employees find it an expensive place to live, and many commute over 2 hours each way to work⁶¹. Boston ranks lower in the combined cluster ranking, but the expense of working in the area and

⁵⁹ Internal analysis of cluster mapping project data, Harvard Business School Institute for Strategy and Competitiveness.

⁶⁰ Only top 20 rankings were given. When an area was not ranked we have assumed a 30 for the calculation. In many cases this is a higher ranking than its actually would be.

⁶¹ Helft, Miguel. *Google's Buses Help Its Workers Beat the Rush*. New York Times. March 10, 2007. Accessed on April 30, 2007 via <http://www.nytimes.com/2007/03/10/technology/10google.html>.

its distance from US ports in the South and Gulf Coast make Boston a suboptimal location for acutely time sensitive cargo and manufacturing operations. Below, in table 8 is the results of an analysis of the costs associated with developing and maintaining a human capital based research and engineering cluster.

Table 8: Affordability Index - select regions⁶²

	Cost of Living	Median Income	Median Home Price	Housing Affordability	Affordability rating (lower number signify more affordable)
New York MSA	212.1	71,300	469,300	6.58	13.96
Los Angeles MSA	153.1	61,700	584,800	9.48	14.51
Philadelphia MSA	119	71,600	230,200	3.22	3.83
Boston MSA	136.8	80,500	402,200	5.00	6.83
San Francisco MSA	177	84,500	736,800	8.72	15.43

The tri-state (Pennsylvania, New Jersey, Delaware) Philadelphia metro region has a stable cluster of the needed industries and significantly lower costs of doing business, living, and staying in the area. The greater Philadelphia region has the workforce, research funding and institutions to support the project. In addition, the local governments have a strong desire to support and grow knowledge-based industries with a skilled manufacturing component. Below are some highlights of the area's labor and research resources and infrastructure.

- Availability of qualified workforce: 42,000 in bioscience⁶³.
- Public research infrastructure: University of Pennsylvania (second in the nation for National Institutes of Health (NIH) funding), Thomas Jefferson University, Children's Hospital of Philadelphia, Temple University Hospital, the Wistar Institute, Fox Chase Cancer Center, Hahnemann Hospital / Drexel University. In 2005, these institutions collectively received more than US \$2.5 billion in NIH funding for research. In addition, more than 20 universities and non-profit institutions were engaged in related research⁶⁴.
- Proximity to research institutions: Four general medical schools, fifteen engineering schools (including Villanova University, one of the participants in this project), a school of osteopathic medicine, two schools of dentistry, two schools of pharmacy, a school of veterinary medicine, a school of podiatry, and a school of optometry.

⁶² Cost of living data from ACCRA, median income from HUD AMI data, median home price data from National Association of Realtors.

⁶³ DeVol, Ross, Koepp, Rob Wallace, Lorna et Al. *The Greater Philadelphia Life Sciences Cluster: An Economic and Comparative Assessment*. Milken Institute. June 2005.

⁶⁴ *The Biosciences in Greater Philadelphia*. Pennsylvania Bio. Accessed on August 6, 2007 via http://www.pennsylvaniabio.org/index.php?option=com_content&task=view&id=18&Itemid=20.

- Cost of living is comparatively lower than other locations with similar advantage profiles. (See Affordability Index of Select Regions, above).

Location Options in the Philadelphia Metropolitan Area

Philadelphia Naval Ship Yard

Basing the research cluster and the TEU design manufacturing storage and maintenance facilities in Philadelphia would optimize project requirement fulfillment and cost effectiveness. Specifically, the Navy Yard facility, with its research and manufacturing mandate, would appear to be the ideal base for activity. In order to accelerate research and design innovation into field operations, it would be preferable to establish the operations center near to the research and TEU projects. This location strategy would create a tight network of formal and informal linkages among stakeholders. The operations center will and should rely heavily on a cohort of other Federal agencies based in the national capital region. Further study is necessary to determine the best way to construct relationship bridges and communication links among the project components, the Navy and other Federal agencies.

The Philadelphia Naval Complex includes the Philadelphia Naval Shipyard, the Philadelphia Naval Station, and the Philadelphia Naval Hospital and is slightly less than 1,500 acres. The Complex is located approximately 4 miles south of Philadelphia's center city⁶⁵, with the shipyard occupying approximately 350 acres. As the nation's first government-owned shipyard, it began operating in Philadelphia's Southwark district in 1801. After Congressional approval in 1867, the land was made available and the Navy officially moved its operations to the Philadelphia Naval Complex.

During its long history, the Philadelphia Naval Complex built 50 new warships, and repaired or renovated 1,218 ships. The main buildings on site were built for industrial use. The complex contained 1,000 buildings, 52 miles of streets and 4.2 miles of waterfront.⁶⁶ The shipyard included buildings like a power plant, foundry, paint shop and an electroplating plant.

Environmentally hazardous organic and inorganic chemicals were stored and used for these operations. From the historic use of this site "prominent site types include landfills and oil spill sites that have released petroleum/oil/lubricants (POLs) and heavy metals to groundwater and soil". Operations produced environmental contaminants including substances such as asbestos, POLs, heavy metals, polychlorinated biphenyls (PCBs), solvents and volatile organic compounds (VOCs).⁶⁷

After more than a century of service, the military's Base Realignment and Closure (BRAC) process, which is used to close surplus military bases, recommended the Naval

⁶⁵ *Philadelphia Naval Complex Current Site Information*. U.S. Environmental Protection Agency. Accessed on October 15, 2007 via <http://www.epa.gov/reg3hscd/npl/PA4170022418.htm>.

⁶⁶ Ibid.

⁶⁷ *Philadelphia Naval Complex*. Accessed on 15 October 15, 2007 via <https://www.denix.osd.mil/denix/Public/Library/Cleanup/CleanupOfc/arc/Reports/FY1994/phillync.html>.

Hospital for closure in 1988 and both the Naval Shipyard and Naval Station for closure in 1991.^{68 69}

Environmental implications of the BRAC closure by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the EPA's National Contingency Plan (NCP) required the Navy to clean up the property for transfer and to disclose the environmental condition of the property. In 1991, after BRAC listed the shipyard and base for closure, preparations for the environmental cleanup began and included "asbestos abatement in buildings, PCB transformer site remediation, removal of underground storage tanks and resulting contaminated soil, and removal and off-site disposal of construction debris and blasting grit".⁷⁰ Most of the cleanup was concluded by 1996, when naval operations at the complex ceased, with a few cleanup areas that were officially completed by 2000.

The PNSY environmental cleanup was the largest cost for the Naval Facilities Engineering Command (NAVFAC), during the closure and transfer process. It cost approximately \$75 million and breaks down to the following figures per fiscal year from 1996 to 1999:

Table 9: Environmental Cleanup Costs for the Naval Shipyard (in thousands of \$)⁷¹

FY 1996	FY 1997	FY 1998	FY 1999	Total
43,799	17,864	7,266	5,768	74,697

**A detailed breakout of these costs follows.⁷²

⁶⁸ *Base Realignment and Closure*. www.GlobalSecurity.org. Last modified November 9, 2005. Accessed on October 15, 2007 via <http://www.globalsecurity.org/military/facility/brac.htm>.

⁶⁹ For the purposes of this report, we will refer to the Philadelphia Naval Complex as only the Philadelphia Naval Shipyard and the Philadelphia Naval Station. The hospital was closed under the 1998 BRAC process and is located approximately three quarters of a mile north of the Naval Shipyard and Station.

⁷⁰ *Philadelphia Naval Complex Current Site Information*. U.S. Environmental Protection Agency. Last updated 3 April 2007. Accessed on October 15, 2007 via <http://www.epa.gov/reg3hscd/npl/PA4170022418.htm>.

⁷¹ Hess et al. *The Closing and Reuse of the Philadelphia Naval Shipyard*. 2001. Information from Table 5.4, p. 46. Accessed on October 15, 2007 via http://192.5.14.110/pubs/monograph_reports/2007/MR1364.pdf.

⁷² Hess et al. *The Closing and Reuse of the Philadelphia Naval Shipyard*. 2001. Table 5.5, Pg 46. Accessed on October 15, 2007 via http://192.5.14.110/pubs/monograph_reports/2007/MR1364.pdf.

Environmental Cleanup Costs at the PNSY
(thousands of dollars)

Environmental Project	Cost
Polychlorinated Biphenyl (PCB)	
Remediation	203
Asbestos Abatement	26,831
Basewide BRAC Cleanup	448
Surveys, Leases, Transfers	2,247
Fuel Farm Contamination	
Remediation	31,549
Building 694 Underground Storage	
Tank Contamination Remediation	364
Lead-Based Paint Remediation	805
One-Time Compliance Projects	12,250
Total	74,697

Figure 8: Environmental Cleanup Costs Breakout

The Navy also conducted an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA), which describes the impacts on the environment of a proposed action. For NEPA, the Navy analyzed the potential environmental impacts of the reuse alternative for its “effects on land use compatibility, socioeconomics, public services, transportation, air quality, noise, cultural resources, natural resources, and generation of hazardous materials.”⁷³

As a result of the NEPA process, the Navy’s Record of Decision for the disposal and reuse of the Naval Complex was published in the Federal Register on July 9, 1997. It called for the community to reuse the facility, which was the City of Philadelphia’s preferred alternative. Reuse was slated for a “mix of industrial, commercial, educational, research and development, residential, warehousing, intermodal transportation and open space uses”.⁷⁴

In August 1998, a Finding of Suitability to Transfer (FOST) from the Navy to the City of Philadelphia was signed for the naval base, and a FOST was signed for the Naval Shipyard in December, 1998.⁷⁵ The land was then transferred to the City of Philadelphia and is managed by the Philadelphia Industrial Development Corporation (PIDC), a private, not-for-profit organization tasked with creating economic development throughout the city.⁷⁶

⁷³ *Record of Decision for the Disposal and Reuse of Naval Base Philadelphia, Pennsylvania*. U.S. Environmental Protection Agency. Accessed on October 15, 2007 via <http://www.epa.gov/EPA-IMPACT/1997/July/Day-09/i17901.htm>.

⁷⁴ Ibid.

⁷⁵ *Philadelphia Naval Complex Current Site Information*. U.S. Environmental Protection Agency. Accessed on October 15 2007 via <http://www.epa.gov/reg3hscd/npl/PA4170022418.htm>.

⁷⁶ *Philadelphia Industrial Development Corporation*. 2007. Accessed on October 15, 2007 via <http://www.pidc-pa.org/>.

The Philadelphia Naval Business Center is now listed as a Brownfields Site by the Pennsylvania Department of Environmental Protection's (DEP) Brownfields Action Team (BAT).⁷⁷ A brownfield site as defined by the EPA is "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."⁷⁸ The Naval Complex's Brownfields Site classification enabled the Federal, state, and local government to contribute \$400 million while Kvaerner, a European company that is now leasing a portion of the shipyard, contributed \$45 million to redevelop and lease a portion of the Complex.⁷⁹

In March 1999, EPA gave PIDC written assurance that the Navy would "continue to be responsible for any environmental contamination on the Philadelphia Navy Yard property when the site is redeveloped. This responsibility would still apply if the property were leased, subleased or re-sold."⁸⁰ Kvaerner/Aker received the same assurance.

⁷⁷ *Brownfields Action Team*. Pennsylvania Department of Environmental Protection (DEP). Accessed on October 15, 2007 via

<http://www.depweb.state.pa.us/landrecwaste/cwp/view.asp?a=1243&Q=462059&landrecwasteNav=30958>.

⁷⁸ Brownfield Definition. U.S. Environmental Protection Agency. Accessed on October 15, 2007 via

<http://www.epa.gov/brownfields/glossary.htm>.

⁷⁹ Hallenbeck, Bob. *Bypassing brownfields: a success story; a "comfort letter" allows a private shipbuilding company to start fresh without the legacy of pre-existing conditions* - Special Report: Environmental Risk & Insurance. July 2003. Accessed on October 15, 2007 via

http://findarticles.com/p/articles/mi_m0BJK/is_9_14/ai_105477040/.

⁸⁰ *EPA Helps Smooth the Way for Navy Yard Redevelopment - Agency Assures Redeveloper that Contamination is Navy's Responsibility*. U.S. Environmental Protection Agency. 15 March 1999. Accessed on October 15, 2007 via

<http://yosemite.epa.gov/opa/admpress.nsf/89745a330d4ef8b9852572a000651fe1/a12cafdeba8cd513852570d60070f9cb!OpenDocument>.

“The United States must improve its ability to deploy civilian expertise rapidly, and continue to increase effectiveness by joining with organizations and people outside of government – untapped resources with enormous potential. We can make better use of the expertise of our universities and of industry...”

– National Defense Strategy, 2008, p. 17

SECTION III. Reachback Needs and Philadelphia

The creation of a phased response system requires a series of reachback capabilities that are currently either missing entirely or spread widely across geographic, departmental and agency boundaries as well as the private and educational sectors. These requirements include:

- On-shore Operations Center to filter and exchange information to and from the decontamination site.
- Integrated research component to expand capability in the field.
- The ability to leverage the commercial sector to expand capability.
- A warehouse to store, repair and restock the TEUs.
- A working port with sea access.
- Design, fabrication, and manufacturing facilities and skills base.

We have identified three primary actions that should fulfill these needs:

1. Create a one-stop Operations Center to respond to and coordinate response to a CBRN event anywhere that the Navy operates at sea
2. Establish a design, fabrication, and maintenance facility for the modular TEU units that this project will use extensively
3. Develop a dedicated research and innovation cluster that draws together DOD personnel, university and other researchers, and the private sector

The Operations Center will supply reachback and research capabilities to those onboard the platform/transport vessel. This Center will be modeled after the existing 24/7/365 DHS operations centers, keeping staff, contractors and watchstanders in constant contact with the bridge of the decontamination vessel.⁸¹ Additionally, the Center will enable vessel personnel to communicate with onshore individuals with appropriate expertise during CBRN situations that may occur.

The TEU design and production facility will translate the conceptual work presented here into prototype units with input from the various participating agencies and special work forces. Once approved, production will be highly technical, will probably generate small batches of units, and will require a great deal of collaboration between the research and production facility. Additionally, the facility will be able to produce, on very short turn around, specialized equipment and other single use items that a decontamination response team requires.

⁸¹ GAO Report 4/5/2007 Department of Homeland Security Coordination of Operations Centers Briefing for House and Senate Appropriation Committees.

The cluster for research and innovation in decontamination technology will be an ongoing activity and will require the creation of a technology and pharmaceutical center to best leverage companies, universities, and related institutions. It is envisioned that this cluster will create and nurture the cross-industrial cooperation needed to promote the development of decontamination methods, research and related capabilities. For example, the research and innovation cluster would nurture synergy between pharmaceutical innovations and technical advances that results in more capable decontamination methods.

Research and Development

The Research and Development Center will leverage the partnerships with the tech sector to find new ways to protect Armed Forces personnel and the public from chemical and biological warfare (CBW). Developing partnerships with area colleges, universities and teaching hospitals will connect specialized programs of study⁸² – e.g., parasitology, virology, molecular biology, microbiology, biochemistry, bioengineering, biomedical neurology, pharmaceutical sciences – to the research and development tools that will produce advances in primary and secondary prophylaxis.

The basing region will require a strong engineering base, a large skilled labor force and a concentration of engineering education to enable students, graduates, professors and researchers to examine the effects of CBRN events on personnel and material and facilitate the creation of a research cluster. Below in Figure 9 is a depiction of the roles and functions that are proposed for the PNSY or similar location.

⁸² Gibbons, Michael T. *Engineering by the Numbers*. American Society for Engineering and Education. Accessed on December 21, 2007 via <http://www.asee.org/publications/profiles/upload/2006ProfileEng.pdf>.

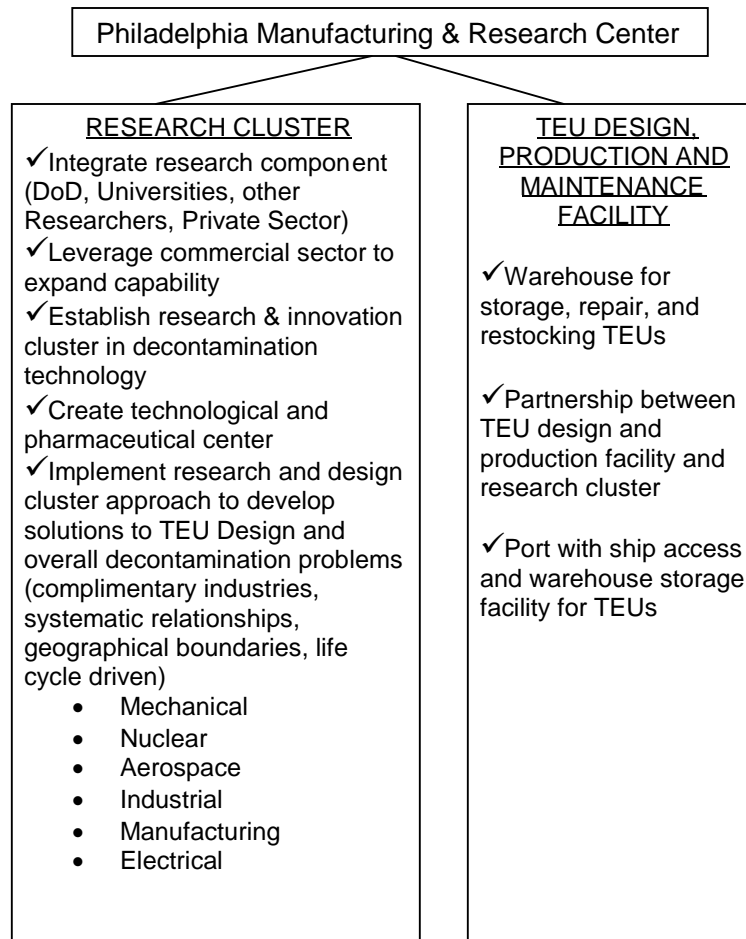


Figure 9: Reachback Needs: Research and TEU Production

Conclusion

This report has started from a different point than the vast majority of US Navy CBRN documents, from the moment after the incident. At some level this differentiated starting point is among its most valuable contributions. Navy has put a lot of hard time and valuable effort into developing ways to detect and defend against a CBRN event, and some of those efforts have paid impressive dividends. Navy however still needs to develop a method of consequence management and property recovery for its increasing expensive fleet. Additionally mitigating the effects of a CBRN event on strategic capabilities lessens the efficacy of such attacks and the Global War on Terror has demonstrated the need for quick and flexible responses. The three phased emergency response system laid out in this report would allow Navy a way forward as it thinks about how to recover and resume operations after the nightmare scenarios we all believe to be just over the horizon. If it changes the discourse from “sink the ship” to how quickly can we safely bring it back into operations and at what cost, both opportunity and financial, it will be ringing success. It can, given additional funding and attention, go several steps beyond that.

Appendix 1: List of Acronyms

ACS	Auxiliary Crane Ship
ALS	Advanced Life Support
AOR	Area of Responsibility
APU	Auxiliary Power Unit
BIDS	Biological Integrated Detections Systems
BLS	Basic Life Support
BRAC	Base Realignment and Closure
CBIRF	Chemical, Biological Incident Response Force
CBR-D	chemical, biological, and radiological defense
CBRN	Chemical, Biological, Radiological, Nuclear
CBW	Chemical and Biological Warfare
CDC	Center for Disease Control
CDD	Capabilities Development Documents
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C ⁴ /IO	Command, Control, Communications, Computers, and Intelligence/ Information Office
CIA	Central Intelligence Agency
CIWS	Close-In Weapon System
CMWDS	Countermeasures Washdown System
CNBC	Center for the Neural Basis of Cognition
CO	Commanding Officer
COBC	Chemical Officer Basic Course
COCOM	Combatant Commanders
COMNAVSEASYS COM	Commander, Naval Sea Systems Command
CONNDOT	Connecticut Department of Transportation
CONUS	Continental United States
COTS	Commercial-off-the-shelf
CPD	Capability Production Documents
CPS	Collective Protection System
CSSC	Civil Support Skills Course
CTMC	Connecticut Maritime Commission
CVBG	Carrier Battle Group
CVN	Aircraft Carrier, Nuclear
DARPA	Defense Advanced Research Project Agency
DC	Damage Control
DECD	Department of Economic and Community Development
DHS	Department of Homeland Security
DHHS	Department of Health and Human Services
DMAT	Disaster Medical Assistance Team
DOD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DRASH	Deployable Rapid Assembly
DU	Depleted Uranium

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EHF	Extremely high frequency
EIS	Environmental Impact Statement
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
ERRDC	Emergency Response Research and Design Center
ET	Electronics Technician
EWS	Early Warning System
FBI	Federal Bureau of Investigation
FC	Fire Controlman
FDA	Food and Drug Administration
FLIR	Forward-Looking Infrared
FOF	Follow-on Force
FOST	Finding of Suitability to Transfer
FRC	Fast Response Cutter
GCCS-M	Global Command and Control System - Maritime
GNF	Graphite Nanofiber
GQ	general quarantine
HAZMAT	Hazardous Materials
HMIRS	Hazardous Material Information Resource System
IC	Interim Communicationman
IED	Improvised Explosive Device
INMARSAT	International maritime satellite
IO	Intel Officer
I/O	Input/output
IPE	Individual Protective Equipment
IS	Intel Specialist
ISO	International Shipping Organization
ISR	Intelligence, Surveillance and Reconnaissance
IT	Info Systems Technician
IT	Information Technology
JACKS	Joint Acquisition CBRN Knowledge System
JHSV	Joint High Speed Vessel
JSFDS	Joint Service Family of Decontamination Systems
JSL	Joint Senior Leader
JWARN	Joint Warning and Reporting Network
JWICS	Joint Worldwide Intelligence Communication System
KIZ	Keystone Innovation Zone
LCAC	Landing Craft, Air Cushion
LEED	Leadership in Energy and Environmental Design
LHD	Amphibious assault ship
MAGTF	Marine air-ground task force
MEDEVAC	Medical Evacuation
MEP	Mobile electric power
MOPP	Mission-Oriented Protective Posture
MPF	Maritime Pre-Positioning Force
MSA	Metropolitan Statistical Area
MSC	Military Sealift Command

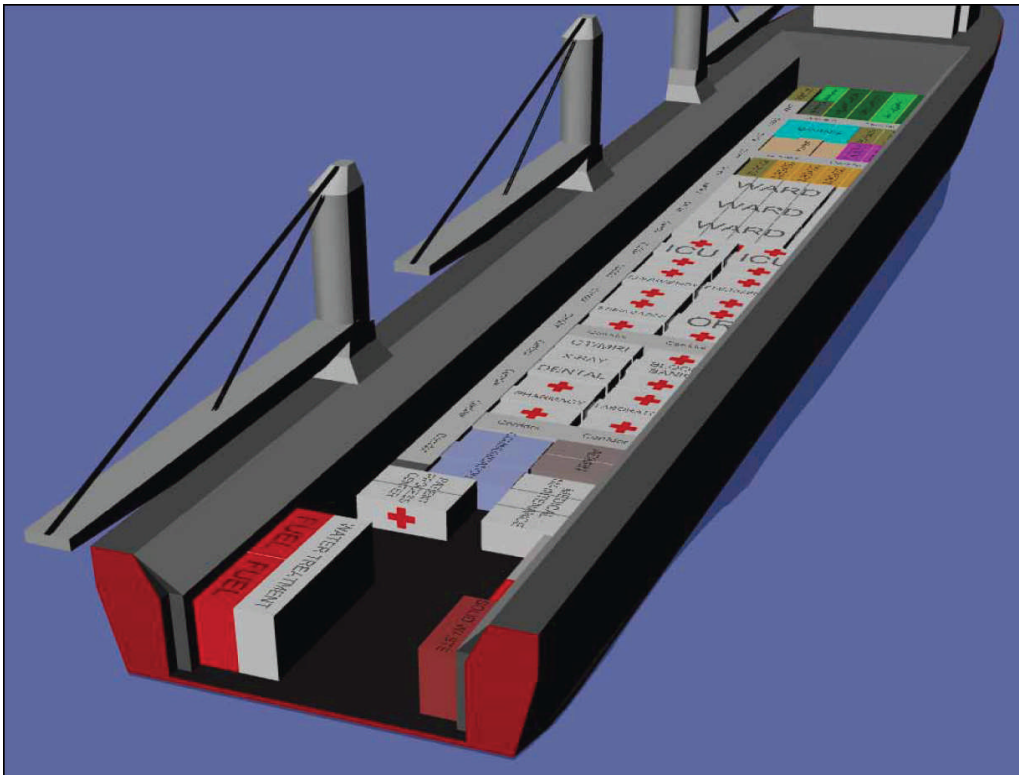
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NASA	National Aeronautics and Space Administration
NAVEDTRA	Naval Education and Training
NAVFAC	Naval Facilities Engineering Command
NAVOSH	Navy Occupation Safety and Health
NBC	Nuclear Biological and Chemical
NCP	National Contingency Plan
NEC	Navy Enlisted Classification
NEPA	National Environmental Policy Act
NIH	National Institutes of Health
NIPRNET	Non-Secure Internet Protocol Router Network
Nm	Nautical Mile
NMR	Nuclear Magnetic Resonance
NOSC	Navy On-Scene Coordinators
NOSCDR	Navy On-Scene Commanders
NRS	National Response System
NRT	National Response Team
NSF	National Strike Force
NSF	National Science Foundation
OCONUS	Outside the Continental United States
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
OPC	Offshore Patrol Cutter
OPRAD	Operational Radiation Safety
OSH	Occupational Safety and Health
PIDC	Philadelphia Industrial Development Corporation
PLSG	Pittsburgh Life Science Greenhouse
PNSY	Philadelphia Naval Shipyard
POLs	Petroleum/Oil/Lubricants
PPE	Personal Protective Equipment
PQS	Personnel Qualification Standard
R&D	Research and Development
RAC	Risk Assessment Code
RADSAFE	Radiological Safety
RAM	Rolling Airframe Missile
RFID	Radio Frequency Identification
ROWPU	Reverse Osmosis Water Purification Unit
RTP	Research Triangle Park
SABT	Static Automatic Bus Transfer
SAR	Search and Rescue
SARS	Severe Acute Respiratory Syndrome
SATCOM	Satellite Communications
SeaRAM	Sea-Launched Rolling Airframe Missile
SHF	Super-high frequency
SIPRNET	SECRET Internet Protocol Router Network
SOP	Standard Operating Procedure
SSN	Attack Submarine, Nuclear

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SWO	Surface Warfare Officer
SUPSALV	Surplus and Salvage
TAK	Cargo ship
TEU	Twenty-Foot Equivalent Unit
TIC	Toxic Industrial Chemical
TS	Top Secret
TTP	Tactics, Techniques and Procedures
TUCASI	Triangle Universities Center for Advanced Studies, Inc.
UAV	Unmanned Aerial Vehicle
UHF	Ultrahigh frequency
USCG	US Coast Guard
USACMLS	United States Army Chemical School
USB	Upper Side Band
USFK	United States Forces Korea
USMC	United State Marine Corps
USN	United States Navy
USPACOM	United States Pacific Command
VHP	Vaporized Hydrogen Peroxide
VOC	Volatile Organic Compound
WHEC	USCG High Endurance Cutter
WMEC	USCG Famous-class and Reliance-class Medium Endurance Cutter
WMD	Weapons of Mass Destruction
XO	Executive Officer

Appendix 2: TEU Specifications



Laboratory Modules

The most unique to the operations, many of these modules will need to be specially constructed.

1. General Laboratory Module - Chemical
2. General Laboratory Module - Biological
3. Nuclear/Radiological Module
4. Property Decontamination Module
5. Decontamination Module
6. Personal Protective Gear Module
7. Toxic Diving Module
8. Sensitive Equipment Decontamination Module
9. Robotics Module

Interdepartmental Modules

Connected intimately with the ops, these modules will house interdepartmental personnel.

1. CDC Module
2. Coast Guard Module
3. EPA Module
4. FDA Module
5. FBI Module

Office/Habitation Modules

These modules require less customization, and will be used primarily by crew.

1. Datacenter Module
2. Media Module
3. General Office Module
4. Mess Hall Module
5. Housing Module
6. First Aid Module
7. Airlock Module
8. Corridor Module

Support Modules

These modules do not require personnel, and are solely infrastructural.

1. Power Generator Module
2. Sewage Treatment Module
3. Waste Removal Module
4. Water Purification Module
5. Storage Module - Uncontaminated
6. Storage Module – Contaminated

Specifications for General Laboratory Module - Chemical

Note: In accordance with industry standards, there will be two General Laboratory Modules, following the model of similar projects—one each for Chemical and Biological testing.

A. Overview

The General Laboratory Module is envisioned as a state-of-the-art portable laboratory, easily configured for any situation that might be encountered. A converted TEU will house equipment and personnel able to test a high volume of material in a very short amount of time, thus identifying CBRN decontaminants more precisely than in Phase I or Phase II. This TEU will contain basic laboratory equipment to do a wide range of tests, and above all a flexible design, allowing a response to all possible situations.

B. Personnel

1. Basic Laboratory Technician

a) Entry-level lab technician, or equivalent, with a bachelor's in Chemistry or related subject.

b) Experience with common equipment and techniques⁸³

1) Gas Chromatograph (GC)

2) Gas Chromatograph/ Mass Spectrometer (GC/MS)

3) ICP instrumentation

4) USEPA SW-846 and 600 Series Methods for organic and inorganic compounds.

2. There will be access to more experienced personnel stationed on land through the Operations Center.

a) Similar to the WMD-CST (Weapons of Mass Destruction Civil Support Team), training to NFPA (National Fire Protection Association) 472 Hazardous Materials (HAZMAT) technician level or above is desirable for this position.

1) The WMD-CST organization is designed to augment local and regional terrorism response capabilities in events known or suspected to involve Weapons of Mass Destruction. WMD events are incidents involving hostile use of chemicals (such as nerve or blister agents, or toxic industrial chemicals (TICs), biological (for example, anthrax or ricin), or radiological source.”⁸⁴

2) 472 hazardous materials technicians have the skills necessary to respond to and mitigate hazardous materials releases. Training to this skill level covers the following:

- Surveying the Incident
- Container ID, Condition, and Marking
- Monitoring Equipment

⁸³ <http://www.newagelandmark.com/emp.php>

⁸⁴ http://c21.maxwell.af.mil/wmd-cst/cst_factsheet_103rd.pdf

- Resource Utilization
- Response Objectives
- Action Option
- Personal Protective Equipment
- Chemical Compatibility
- Developing Action Plans
- Incident Management
- Control Functions
- Evaluation Progress
- Incident Termination
- Field Exercises⁸⁵

Having someone of this skill level available for consultation will allow the laboratory technicians to complete their routine work, but defer to the more experienced personnel if/when something unusual occurs.

3. While there is no equivalent rating, this position will be similar to the Army position Chemical Operations Specialist (74D)⁸⁶.
 - a) Equivalent civilian jobs can be found at all levels of government and in private agencies.
4. Two technicians will be assigned to this TEU, due to the constraints of space. With the flexibility in changing the working environment, more technicians may be added as needed, when possible.

C. Equipment

1. Environment⁸⁷
 - a) Independent climate control and ventilation
 - b) Counter space should have the ability to be moved to accommodate personnel and equipment.
2. Sink and sample prep area
3. Separate analysis and extraction areas, to avoid cross-contamination
4. General Laboratory Equipment⁸⁸
 - a) Freezer space for samples
 - b) Computer system, networked with other modules and onshore personnel
 - c) Seawater and compressed air connections
 - d) GC and GC/MS units
 - e) Glovebox
 - f) XRF and/or Mercury Analyzer technologies
5. Efficiency

⁸⁵<http://www.teex.com/teex.cfm?pageid=training&area=TEEX&templateid=14&Division=ESTI&Course=HAZ020>

⁸⁶ <http://www.goarmy.com/JobDetail.do?id=40>

⁸⁷ <http://www.moc.noaa.gov/rb/science/labs.htm>

⁸⁸ <http://www.newagelandmark.com/labs.html>, http://c21.maxwell.af.mil/wmd-cst/cst_factsheet_103rd.pdf, http://www.ecbc.army.mil/uf/mobile_labs.htm

- a) Ideally, the General Laboratory should have capabilities to process several hundred samples a day, with an average turn-around time of 24 hours⁸⁹. Preliminary decontamination sample collection and identification will have taken place already in Phases I and II, so that the Laboratory will only need to identify the contaminants more precisely so as to facilitate further decontamination.
- b) Throughout the design process, flexibility should be given high priority. The equipment and environment of the module should be changeable as much as practically possible, allowing counter space to be configured as needed. The module should be able to accommodate a wide variety of equipment.⁹⁰

D. Environmental Considerations

- 1. Standard maritime technology, such as the use of waterproof keyboards, tie-down railings around counter space and similar should be implemented.⁹¹
- 2. Dedicated environmental controls and venting should be utilized to prevent possible cross-contamination.

E. Agency Partnerships

- 1. Partner personnel will most likely be stationed at the operations center, or in another TEU, and will fill an advisory role.
 - a) Center for Disease Control
 - 1) Generally will liaise only with the Biological TEU, but may be needed for other CBRN knowledge.
 - b) State Agencies, as applicable
 - 1) This will become necessary in littoral areas, where civilian populations may be affected by the CBRN agents detected.
- 2. Because this module is concerned with testing only, we do not foresee a great need for physical co-location with other agencies personnel.

F. Operation Center

- 1. This TEU will have the ability to be in constant communication with the onshore Operations Center, through the C⁴I/IO, via a variety of technologies.
 - a) VOIP, online messaging and videoconferencing (using technology in the Datacenter module) will all be available for immediate contact. For exchanging documents, a VPN connection can be used so that two parties have access to the same documents.
 - b) Exchange of information between cleanup site and shore will be instantaneous.

⁸⁹ http://www.ecbc.army.mil/uf/mobile_rtap.htm

⁹⁰ <http://www.moc.noaa.gov/rb/>

⁹¹ <http://www.moc.noaa.gov/rb/science/labs.htm#labsurface>

Specifications for General Laboratory Module: Biological

A. Special Considerations

1. Technology, personnel and design to be identical to the General Laboratory Module.
 - a) Further biological testing-specific technology may be called for.
2. Industry standard calls for a separate area specifically for biological laboratory space, to avoid cross-contamination and the possibility of unintentionally spreading biological contaminants.⁹²
 - a) An independent climate-control and venting system is absolutely vital to this module.

⁹² <http://www.moc.noaa.gov/rb>, <http://www.newagelandmark.com/labs.html>

Specifications for Nuclear/Radiological Module

A. Overview

The Nuclear/Radiological Module is a mobile laboratory utilized in response to an array of incidents ranging from shipping accidents to the detonation of radiological dispersal devices. The NR module is outfitted with numerous testing systems to identify radioactive contaminants and determine the potential risk posed to working personnel as well as the vessel itself. The information provided by this module will be used to design an effective decontamination operation tailored to each individual incident.

B. Personnel

1. Damage Controlman Third Class (DC3)⁹³
 - a) Civilian equivalent of this position is a Certified Health Physicist⁹⁴
2. Prior training with all radiation detection equipment and experience with handling radioactive material are essential.
3. Responsibilities include the following:⁹⁵
 - a) Operate radiation detection instruments
 - b) Identify radioactive contaminants
 - c) Map the location and intensity of contamination based on air samples
 - d) Compute radiological stay times
 - e) Relay all information to working personnel
 - f) Aid executive personnel in determining the ideal decontamination procedure and the protective clothing that will be needed
 - g) Maintain the cleanliness of all equipment
4. Personal Protective Gear must be worn by NR Module personnel at all times.
 - a) Computers will be used as a means of communication between the NR Module personnel and other personnel on site and on shore.
 - b) Two-way radios can also be used to maintain contact with other modules.

C. Equipment

1. Radiation detection instruments will test air samples from multiple sections of the contaminated area.
 - a) Survey meters with Geiger-Mueller probes detect and measure contamination.⁹⁶
 - b) Spectrometers identify radionuclides and determine dose rates.⁹⁷
2. Personal electronic dosimeters will be clipped to the belts of the NR Module personnel when working near a radiation source or handling contaminated material.⁹⁸

⁹³ http://buperscd.technology.navy.mil/bup_updt/508/OccStandards/CHAPTER%2021.htm#dc1

⁹⁴ <http://www.hps.org/>

⁹⁵ http://www.doza.ru/eng/catalog/movable_labs/mobile_laboratory_poisk.shtml

⁹⁶ http://www.biodex.com/radio/detection/detection_007.htm

⁹⁷ <http://www.xrfcorp.com/products/ics-4000.html>

- a) The dosimeter measures the rate of exposure to and the dose of radiation that the wearer experiences.
 - b) A mixture of light, sound, and vibration resonating from the dosimeter will warn the wearer when preset dosage thresholds are passed.
 - c) At a 2.5 R dose the working personnel must retire from the NR Module and undergo examination by a medical physician.
3. Collapsible counter space along the TEU walls will give personnel an area for operating radiation detection instruments and testing air samples.
 4. Computers with remote monitoring software will log data and transfer information to C⁴I/O, and via them to the onshore Operations Center.⁹⁹
 5. One storage closet will house all radiation detection instruments.
 6. A generator will provide power for lighting and electrical equipment.
 7. A ventilation system unique to the NR Module will circulate new air into the NR Module while preventing cross-contamination between TEUs.

D. Efficiency

1. The NR Module will have the capacity to test all first-round samples within the first 24 hours of operation.
2. After the first round of testing, all new samples will be tested based on priority.
3. Results will be determined and relayed to executive personnel within one hour of testing.

E. Environmental Considerations

1. All equipment and furnishings inside the TEU will be capable of undergoing decontamination in the event of direct exposure to radiation.
2. All storage containers will be secured and tie-down straps will be installed on the counter space for additional safety during transport and rough seas.

F. Operations Center

1. The Operations Center will be connected to the NR Module's computer software in order to gain up-to-date information from the contamination site.
2. Experts working in the Operations Center will need to have access to the following data:
 - a) Which radioactive contaminants are involved in the incident
 - b) The dosage and intensity of contamination
 - c) The size of the contaminated area
 - d) What hazards are posed to working personnel
 - e) Which treatment options are available for decontaminating the vessel and its equipment

G. Agency Partnerships

1. Environmental Protection Agency¹⁰⁰

⁹⁸ http://hps.org/hsc/documents/Radiation_detection.pdf

⁹⁹ http://www.thermo.com/com/cda/newsevents/news_detail/1,,11761,00.html

¹⁰⁰ http://www.epa.gov/radiation/rert/monitoring.htm#how_monitor

- a) The EPA's Radiological Emergency Response Team (RERT) specializes in responding to radiation-related incidents.
- b) Members of the RERT are experienced in using two Mobile Environmental Radiation Laboratories during operations to detect and measure radiation.
- 2. Centers for Disease Control and Prevention¹⁰¹
 - a) Under the National Response Plan, the CDC is designated to protect the health of everyone on site following a radioactive incident.
 - b) The CDC will ensure the safety of the NR Module's personnel and provide information on the specific hazards posed by the radioactive contaminants that are identified.
- 3. State Agencies, where appropriate
 - a) When civilian populations are threatened by an incident near shore, officials from state agencies can be reached through the Operations Center.

H. Similar Projects

- 1. Bhabha Atomic Research Centre¹⁰²
 - a) The compartmentalized Mobile Radiological Laboratory (MRL) designed by this Indian nuclear research facility incorporates a computer laboratory and many radiation measuring devices.
 - b) The MRL is designed to run autonomously for up to two weeks.
- 2. The National Air and Radiation Environmental Laboratory¹⁰³
 - a) The NAREL, managed by the U.S. EPA, has designed a mobile radio analysis laboratory for the Republic of Ukraine.
 - b) The mobile lab is compact enough to be transported by a standard eighteen wheeler truck.
 - c) Numerous testing systems are built into the mobile lab, including some that can be converted into chemical agent analyzers.
- 3. Lokmis¹⁰⁴
 - a) The compact mobile laboratory produced by this Lithuanian company can test samples from a nuclear or radiological accident using a range of the company's own measuring equipment.
 - b) This laboratory provides an ideal model for rapid radiation detection in a contained area of operation.

¹⁰¹ <http://www.bt.cdc.gov/radiation/cdcrole.asp>

¹⁰² <http://www.dae.gov.in/ni/nimjun03/mobile.htm>

¹⁰³ <http://www.epa.gov/narel/ukraine.html>

¹⁰⁴ <http://www.lokmis.lt/en/Ionizingradiationregistrationequipment/MobileLaboratories/tabid/783/Default.aspx>

Specifications for Property Decontamination Module

A. Overview

This module will focus specifically on testing decontamination procedures on large-scale objects. It will have the ability to decontaminate samples of the ship itself, furniture, etc., while monitoring the effectiveness of procedures on a variety of materials. It is envisioned that this module will work closely with the General Laboratory Module, but will be separate and dedicated to testing CBRN decontamination procedures as opposed to analyzing samples to detect the specific type of decontamination. This module will consist entirely of laboratory space, with office work to be done in a separate general office module, or to be done onshore after the information is transmitted over communication lines (VOIP, VPN, etc.).

B. Personnel

1. Basic Laboratory Technician

- a) Entry-level lab technician, or equivalent, with a bachelor's in Chemistry or related subject.
- b) Experience with common equipment and techniques¹⁰⁵
 - 1) Gas Chromatograph (GC)
 - 2) Gas Chromatograph/ Mass Spectrometer (GC/MS)
 - 3) ICP instrumentation

4) USEPA SW-846 and 600 Series Methods for organic and inorganic compounds.

2. There will be access to more experienced and knowledgeable personnel stationed on land via the Operations Center and C⁴I/O.

- a) Similar to the WMD-CST (Weapons of Mass Destruction Civil Support Team), training to NFPA (National Fire Protection Association) 472 HAZMAT technician level or above would be valuable.

1) "The WMD-CST organization is designed to augment local and regional terrorism response capabilities in events known or suspected to involve Weapons of Mass Destruction. WMD events are incidents involving hostile use of chemicals (such as nerve or blister agents, or toxic industrial chemicals - TICs), biological (for example, anthrax or ricin), or radiological source."¹⁰⁶

2) 472 hazardous materials technicians have the skills necessary to respond to and mitigate hazardous materials releases. Training to this skill level covers the following:

- Surveying the Incident
- Container ID, Condition, and Marking
- Monitoring Equipment
- Resource Utilization
- Response Objectives

¹⁰⁵ <http://www.newagelandmark.com/emp.php>

¹⁰⁶ http://c21.maxwell.af.mil/wmd-cst/cst_factsheet_103rd.pdf

- Action Option
- Personal Protective Equipment
- Chemical Compatibility
- Developing Action Plans
- Incident Management
- Control Functions
- Evaluation Progress
- Incident Termination
- Field Exercises¹⁰⁷

Having someone of this skill level within easy communication will allow the laboratory technicians to complete their routine work, but also have someone to consult if necessary if/when something unusual occurs.

3. While there is no equivalent rating, this position will be similar to the Army position Chemical Operations Specialist (74D)¹⁰⁸.
 - a) Equivalent civilian jobs can be found at all levels of government and in private agencies.
4. Two technicians will be assigned to each TEU, due to the constraints of space. With the flexibility in changing the working environment, more technicians may be added as needed, space allowing.

C. Equipment

1. This module will need access to pressurized water and air.
 2. Drainage in the testing area will need to be routed to special containment.¹⁰⁹
 3. Personal Protective Gear is essential.
 4. The module will need access to all decontamination materials that will be used on the ship in sufficient quantities to test a variety of larger objects.
 5. This module will also need the necessary equipment to test the contamination levels of the objects being worked on.
 - a) As in the decontamination of the Hart Building, test strips can be used to measure the levels of contamination remaining.¹¹⁰ Detection tickets and detection tubes will be standard equipment.¹¹¹
 - b) The module will be able to determine the following: the performance of the contaminant and decontamination products; the effectiveness of the restoration method; the cost and duration of the decontamination, cleaning, or neutralization material; and the contamination resulting from the cleanup.¹¹²
1. Storage capabilities

¹⁰⁷<http://www.teex.com/teex.cfm?pageid=training&area=TEEX&templateid=14&Division=ESTI&Course=HAZ020>

¹⁰⁸ <http://www.goarmy.com/JobDetail.do?id=40>

¹⁰⁹ Ibid.

¹¹⁰ <http://yosemite.epa.gov/opa/admpress.nsf/a16b318fd6d8e076852572a000650bfff93e59a8346b3cf985256b1700590dcb!OpenDocument>

¹¹¹ http://www.gulflink.osd.mil/marine_breaching_ii/marine_breaching_ii_refs/n34en232/detect.htm

¹¹² http://www.crti.drddc.gc.ca/en/investments/technology_demonstration/04_0019td.asp

- a) Storage will not be indefinite.
- b) The storage capabilities will have to be able to handle large samples such as parts of the ship, furniture and other large objects in addition to temporary storage for liquid and solid detritus after the decontamination is complete.¹¹³
- c) Due to the potentially large objects, storage may require multiple, entirely separate TEUs.

D. Environmental Considerations

- 1. Standard maritime precautions will be taken to address the effects of water and movement on equipment.

E. Agency Partnerships

- 1. DOD/Defense Advanced Research Projects Agency (DARPA)
 - a) “DARPA’s TIGER (Triangulation Identification for Genetic Evaluation of Risk) program has developed a universal sensor that can detect any type of pathogen – even unknown and engineered ones – through an innovative method of measuring and weighing nucleic acid sequences.”
 - b) DARPA is also working closely with the FDA and DHS to develop and refine techniques for detection, decontamination and remediation of areas that have suffered CBRN attacks.¹¹⁴
- 2. DHS and FDA
 - a) Working with DARPA to develop techniques for detection and decontamination of CBRN events.
- 3. Local authorities
 - a) As necessary, the results from the tests conducted in these modules may need to be passed on to local government/DHS/EPA, if the contaminated ship is near civilians.

F. Operations Center

- 1. The Property Decontamination TEU will have onshore experts at the Operations Center, similarly to the General Laboratory TEU. This way they will be able to consult the necessary personnel if needed, but also be able to handle the usual work.

G. Similar Projects

- 1. This style of decontamination is similar to that done at the Hart building during the 2001 anthrax incident.¹¹⁵ Decontamination methods were tested in a nearby trailer to evaluate the effectiveness and the dosage level needed to properly clean the area and the objects in it.

¹¹³ <http://www.ukresilience.info/emergencies/cbrn/defra/management.aspx>

¹¹⁴ http://72.14.205.104/search?q=cache:hqHdNaHxe70J:www.arpa.mil/body/news/2005/tethertestim7_21_05.pdf+CBRN+remediation+testing&hl=en&ct=clnk&cd=9&gl=us&client=firefox-a

¹¹⁵ Reopening Public Facilities After a Biological Attack: A Decision-Making Framework

Specifications for Decontamination Module

A. Overview

The Decontamination Module is a fully-equipped mobile storage facility designed to safely house and transport decontamination equipment to the site of contamination. With the capacity to store and support a wide variety of decontamination systems, this TEU is well-suited to handle a multitude of CBRN incidents. An efficient decontamination operation relies heavily upon the flexibility and preparedness of the Decontamination Module.

B. Personnel

1. Damage Controlman Third Class (DC3) Navy rating¹¹⁶
 - a) Civilian equivalent of this position is a Facilities Maintenance Specialist.
2. Two ratings will be assigned to each TEU, due to the constraints of equipment space
 - b) When available, increased specialization of the equipment can allow for more personnel to work from each TEU.
 - c) Additional personnel for instruction or consultation are available on land through the Operations Center.
3. Will operate all decontamination systems housed in the TEU
 - a) Personnel should be familiar with handling the different systems onboard and should receive formal training as to their proper use.
4. Personal Protective Gear must be worn at all times

C. Equipment

1. Interior lighting
2. Dry containers to store decontaminants
3. Ample shelving for the decontamination systems
4. General equipment to support decontamination systems
 - a) Electric generator to be used as a back-up energy supply and to run decontamination systems that are not self-powered.
 - b) Water intake system must be capable of heating and pressurizing water.¹¹⁷
 - c) Drainage system to safely remove water and waste from the module floor

D. Operation

1. Multiple decontamination systems should be included to tailor the decontamination effort to as many potential situations as possible.
 - a) Take into consideration the following circumstances:
 - 1) Size of contaminated area
 - 2) Type of material contaminated

¹¹⁶ http://buperscd.technology.navy.mil/bup_updt/508/OccStandards/CHAPTER%2021.htm

¹¹⁷ http://www.forces.gc.ca/admmat/dglepm/cfnbcds/documents/SOW_Appendix_1_-_Module_1_Specification.DOC

- 3) Type of chemical/biological agent
 - b) Systems should be compatible with multiple decontaminates.¹¹⁸
 - 1) Liquid-based topical agents
 - 2) Foams and gels
 - 3) Gaseous and vapor technologies
 - c) Systems should be capable of running autonomously or with the aid of utilities provided by the module itself.
2. The module should allow for easy roll-on/roll-off loading and unloading of all equipment.
 - a) Neither setup nor takedown should require more than 30 minutes.
3. Each TEU should have the capacity to decontaminate 10,000 square meters per hour.¹¹⁹
4. All used equipment will be cleaned and verified contamination-free before being repackaged inside the TEU.

E. Environmental Factors

1. The interior of the TEU can be cleaned in the event of direct exposure to contamination.
2. Great care must be taken to secure the module's contents before transportation so as to ensure their safe arrival at the maritime site.
 - a) Supply stable containment for bottles of liquid and foam decontaminates.
 - b) Bolt shelving to the floor and walls.
 - c) Each system will be individually packaged and secured to the module's shelves.

F. Operations Center

1. Personnel working from the Decontamination Module can communicate with onshore experts to determine the best decontamination methods to use for a specific incident.
 - a) Experts must be familiar with the decontamination systems onboard the response vessel as well as the environments in which each system should be used.
2. The Operations Center will have access to a chemical/biological agent database such as the EPA's Contaminant Data Dictionary.¹²⁰

G. Agency Partners

1. U.S. National Response Team (NRT)¹²¹
 - a) NRT's Regional Response Teams are well-versed in providing technical assistance and coordinating the attainment of additional manpower and equipment during emergency incidents involving hazardous substances.

¹¹⁸ <http://www.epa.gov/nhsr/pubs/reportBuildDecon052705.pdf>

¹¹⁹ <http://www.allen-vanguard.com/Catalogue/CB/613/909498.html>

¹²⁰ <http://www.epa.gov/ordnhsr/news/news120606.html>

¹²¹ <http://www.nrt.org/>

2. Center for Disease Control¹²²
 - a) Personnel from Bioterrorism and Chemical Emergencies areas with information on the chemical or biological agent should remain on call until decontamination has been completed and the agent eliminated.

H. Similar Projects

1. Karcher Futuretech GmbH¹²³
 - a) Multiple compact and easily transportable decontamination systems are already manufactured by Karcher for an array of NBCR incidents.
2. OWR¹²⁴
 - a) A compact, adaptable containerized system developed by this German firm is used for the decontamination of personnel, buildings, clothing, and equipment.
 - b) The system, which was designed to be transported via truck, demonstrates consideration to space, mobility, and easy setup.
3. PW Allen & Company and Canadian Vanguard Response Systems¹²⁵
 - a) Allen-Vanguard has developed the compact CASCAD Universal Decon Module, a self-contained military decontamination system designed for rapid deployment to an incident site.
 - b) Foam-based Allen-Vanguard decontamination equipment is stored inside the module to be used on vehicles, aircraft, and ships.
 - c) The CASCAD system can decontaminate roughly 10,000 square meters each hour.

¹²² <http://www.bt.cdc.gov/>

¹²³ http://www.karcher-futuretech.com/futuretech/Products/NBC_Protection_Systems/Decon_Systems.htm

¹²⁴ http://www.owr.de/go/owr/home/products/multi_purpose_decont/containerised_decontamination_system/1.xhtml

¹²⁵ http://www.vanguardresponse.com/products_im_decon.shtml

Specifications for Personal Protective Gear Module

A. Overview

The Personal Protective Gear Module is a portable supply container, stocked with a range of equipment and clothing to protect against chemical and biological agents. In order to reduce direct contact with hazardous material, this module is to be used by multiple shifts of personnel from all vessels until decontamination has been completed.

B. Layout

1. The majority of the inside space of this TEU will be reserved for storing protective equipment.
 - a) Shelving and containers should be secured to the walls and floor and labeled as to their contents.
 - b) The design of the TEU must provide for quick and easy access to all protective gear.
2. A portion of the TEU will be reserved as a dressing area for personnel.
3. All areas should be well-lit and have open walking spaces for optimum use of the module during emergencies.

C. Supply of Protective Gear

1. Personnel from the response vessels as well as crewmembers of the contaminated vessel will be supplied by this TEU.
2. All protective clothing and equipment must be easy to maneuver in and able to withstand thorough decontamination after use.
3. Each article of protective gear will be operable by itself as well as in conjunction with other personal equipment.
4. Will include the following:
 - a) Full-body over suit and hood equipped with respiration system.¹²⁶
 - 1) Zipper front for easy donning
 - 2) Double seamed for extra protection
 - 3) Must ensure prime visibility through face mask
 - b) Full-body over suit without head cover.
 - c) Standalone respiration mask to be used when no personal protective suit is deemed necessary.
 - 1) Filters airborne agents while still allowing for verbal communication.¹²⁷
 - d) Brightly colored hardhats with adjustable chinstraps
 - e) Impermeable steel-toed boots
 - 1) Stretch-fasteners will allow for easy donning and snug fitting.¹²⁸
 - f) Textured gloves resistant to chemical permeation and degradation.¹²⁹

¹²⁶ http://nbcprotect.com/products/protective_item109.htm

¹²⁷ <http://www.allen-vanguard.com/Catalogue/PP/612/909419.html>

¹²⁸ http://nbcprotect.com/products/nbcaccessories_1000.htm

¹²⁹ <http://www.safetysupplyequipment.org/glovestd.htm>

- g) Personal cooling systems to be used during times of high temperatures.
- h) Waterproof battery-powered radios that clip to the over suit waistband.
- 5. All equipment will be stocked in multiple standard sizes to accommodate all personnel.
 - a) Before deployment, all clothing may be assigned and fitted to response personnel instead of being used in rotation.
- 6. Each TEU should hold supplies for no less than 20 personnel.

D. Personnel

- 1. Master-at-arms Second Class (MA2) Navy rating¹³⁰
 - a) Civilian equivalent of this position is a Safety, Health and Environmental Coordinator.
- 2. Space allowing, assign two ratings per TEU to maintain suits and storage.
- 3. Training and familiarity with all equipment is required.
- 4. Experience in high-threat level incident response and special protective equipment is recommended.
- 5. Responsibilities include the following:
 - a) Overseeing the allocation of all equipment.
 - b) Instructing personnel on the proper usage of the personal gear
 - c) Making equipment adjustments when necessary
- 6. Written instructions complete with diagrams showing proper equipment use should also be posted at eye-level on the TEU walls.

E. Environmental Considerations

- 5. All contents of the TEU should be secured inside closed containers due to the possibility of inclement weather and rough seas.
- 6. The simplistic design of the module allows personnel to rapidly retrieve necessary protective equipment even in the worst weather, maritime, or HAZMAT conditions.
- 7. All personnel entering the TEU during a CBRN incident will first be decontaminated to ensure that no hazardous material enters the container.

F. Agency Partnerships

- 1. National Institute of Standards and Technology¹³¹
 - a) This institute is developing standards for protective equipment for the Department of Homeland Security.
 - b) Information from the NIST will be vital in determining the most appropriate protective gear for all potential situations.
- 2. PHMSA Office of Hazardous Materials Safety¹³²
 - a) Trainers well-versed in HAZMAT response can aid in overseeing that all personnel are properly protected and using all protective equipment correctly.

¹³⁰ <http://www.navcops.com/magazine/articles/12/10/History-of-the-Master-At-Arms-%28MA%29-Rating>

¹³¹ http://www.nist.gov/public_affairs/factsheet/protective_equipment.htm

¹³² http://hazmat.dot.gov/contact/ohhms_fn.htm

G. Operations Center

1. Experts working in the Operations Center will keep all personnel informed as to the extent of protective gear necessary for every task and phase of the response process.
2. Personnel involved in the decontamination process can maintain communication and exchange information with the Operations Center at all times via radio.

Specifications for Toxic Diving Module

A. Overview

This module will store the supplies needed for any diving that may need to take place in waters in and around the CBRN-contaminated ship. It will not have decontaminating apparatus, but may store contaminated diving gear if necessary. There will be a sister module physically separate from this one for general office work and keeping in constant contact with divers.

B. Personnel

Personnel shall consist of a minimum of two divers and one contact person to remain onboard the platform/transport vessel.

1. Divers should have completed the Navy's Fleet Diver Program¹³³ and received specialized training in working in a contaminated diving atmosphere.
2. Non-diving personnel will keep in constant radio contact with the divers, and relay findings to the Operations center and other module personnel if necessary.
3. Civilian equivalent jobs are less common due to civilians rarely needing to dive in CBRN waters. Similar jobs, though, can be found in government and some police forces. The NYPD SCUBA division, for example, often does harbor diving in TIC/TIM contaminated waters.¹³⁴

C. Equipment

1. This module will store clean diving gear, with the possibility for also storing post-dive contaminated equipment.
2. Thus the module will have two sets of storage bins, one to only be used for clean gear, the other only for contaminated gear until it can be cleaned, either on the ship or once the ship returns to port.
3. Specific Equipment
 - a) Dry suits fitted for all potential personnel (assuming that this module will be staffed on a rotating schedule), in addition to a range of sizes that can be used if needed by other personnel.
 - b) Breathing apparatuses for the two divers, as well as at least one backup apparatus. These should be specifically constructed for use in CBRN environments and have a completely closed-loop air recycling system.¹³⁵
 - c) Two oxygen tanks for use by the divers, and two backups. These should be kept full at all times.

D. Environmental Considerations

1. Storage, especially for potentially-delicate equipment such as SCBA breathing apparatuses will be fastened securely to minimize movement in rough weather conditions.
2. Oxygen tanks will be stored in fireproof containers.

¹³³ <http://usmilitary.about.com/od/enlistedjob1/a/diver.htm>

¹³⁴ <http://www.nyc.gov/html/nypd/html/pct/sodpct.html>

¹³⁵ <http://www.virtualacquisitionshowcase.com/docs/Paragon-Brief.pdf>

3. All delicate equipment will have customized storage bins as much as possible, to prevent it from moving while stored.

E. Agency Partnerships

1. Navy Experimental Diving Unit¹³⁶

- a) A division of the Navy Diving Unit, this unit (under NAVSEA) researches, tests and evaluates equipment and techniques for use in undersea, hyperbaric, and other life-support situations. In addition to training CBRN-ready divers, they will be invaluable for testing a research of new diving apparatus.

2. CDC

- a) The CDC has developed NIOSH testing, certification, and guidelines for CBRN SCBA gear that will fully protect the diver. The divers can work with the CDC to ensure that their equipment will sufficiently protect them, as well as potentially test and develop new equipment.¹³⁷

F. Operations Center

1. The Operations Center may be able to tune into the radio between divers and the ship. In addition they will receive all data related to the divers' findings and be able to disseminate it to both on-land personnel and other personnel aboard the platform/transport vessel.

G. Similar Projects

1. Paragon Space Development Corporation¹³⁸

- a) Although primarily tasked with researching and designing equipment for NASA, Paragon has developed a CBRN diving apparatus.

- b) Paragon, working off of the evidence that traditional diving equipment protects the diver for only 5 – 15 minutes, developed a breathing system that is completely self-contained, isolating the diver from his or her environment.

2. Current technology

- a) Current baseline Navy technology consists of the Kirby Morgan superlite 17b helmet, also known as the MK21 or the MK37/Viking dry suit combination.

- b) Although adequate in many ways, the current technology has a lot of weaknesses where CBRN contaminants can enter and come into contact with the diver.

- 1) For example, the MK21 stops preventing water intrusion when the diver's head moves from the upright position.¹³⁹

¹³⁶ <http://www.supsalv.org/NEDU/nedu.htm>

¹³⁷ <http://www.cdc.gov/niosh/npptl/pdfs/CBRNSCBAJuly15.pdf>

¹³⁸ http://www.paragonsdc.com/chem_bio_hazard.php

¹³⁹ <http://www.virtualacquisitionshowcase.com/docs/Paragon-Brief.pdf>

Specifications for the Sensitive Equipment Decontamination Module

A. Overview

This module will decontaminate sensitive equipment encountered during the whole-ship decontamination after a CBRN event. Sensitive equipment includes avionics, electronics, environmental control systems, life support systems, and other objects which could potentially be harmed by the standard caustic decontaminants.

B. Personnel

1. Space allows for approximately 2-3 persons at any time.
2. Personnel should have training in decontamination procedures, and experience or equivalent training in CBRN decontamination specifically, preferably to a 472 HAZMAT technician level or above.¹⁴⁰
 - a) 472 hazardous materials technicians have the skills necessary to respond to and mitigate hazardous materials releases. Training to this skill level covers the following:
 - Surveying the Incident
 - Container ID, Condition, and Marking
 - Monitoring Equipment
 - Resource Utilization
 - Response Objectives
 - Action Option
 - Personal Protective Equipment
 - Chemical Compatibility
 - Developing Action Plans
 - Incident Management
 - Control Functions
 - Evaluation Progress
 - Incident Termination
 - Field Exercises¹⁴¹
3. While there is no equivalent rating, this position will be similar to the Army position Chemical Operations Specialist (74D)¹⁴².
 - a) Equivalent civilian jobs can be found at all levels of government and in private agencies.
 - 1) Although there is not a great call for decontamination personnel in the civilian world, many private agencies are working on developing sensitive equipment decontamination procedures.¹⁴³

¹⁴⁰ http://c21.maxwell.af.mil/wmd-cst/cst_factsheet_103rd.pdf

¹⁴¹ <http://www.teex.com/teex.cfm?pageid=training&area=TEEX&templateid=14&Division=ESTI&Course=HAZ020>

¹⁴² <http://www.goarmy.com/JobDetail.do?id=40>

b) Navy EOD forces also receive similar training, particularly as concerns responding to terrorist threats.¹⁴⁴

C. Equipment

This module will primarily feature autoclave-like closed-loop decontamination systems to safely decontaminate small objects. It will have the ability to safely decontaminate large areas onboard ship, as well.

1. Small-scale decontamination

a) There will be several small, closed-loop systems approximately the size of a dishwasher that will be able to decontaminate small items, such as laptop computers or night-vision goggles.¹⁴⁵

b) This system will wash the object with a 'friendly' decontaminant such as ACES, an enzyme-based decontaminant developed by Edgewood.¹⁴⁶

This non-corrosive, non-flammable material will neutralize the decontaminant, and the remaining material can be flushed away and safely disposed of.¹⁴⁷

D. Environmental Considerations

1. Extreme caution should be taken in securing objects, and particularly in the method in which the equipment being decontaminated is secured within the closed-loop system, due to the sensitivity of everything involved. Aside from that, standard maritime cautions should be taken.

E. Agency Partnerships

1. EPA

a) "The EPA and other agencies will develop standards, protocols, and capabilities to address the risks of contamination following a biological weapons attack and developing strategies, guidelines, and plans for decontamination of persons, equipment, and facilities."¹⁴⁸

b) This TEU may turn to the EPA to get information about specific decontamination procedures, as there will be different procedures used than for large-scale decontamination.

2. CDC

a) If needed, this TEU will liaise with members of the CDC in order to collect and share information about decontamination procedures. It may also become necessary to consult with the CDC on how to transport and safely handle the byproducts of CBRN decontamination.

¹⁴³ http://nationalsecurity.battelle.org/clients/inno_related.aspx?id=44,
<http://www.enviroexperts.net/deconindclean.htm>, <http://www.smiths-aerospace.com/News/Archive/2002/Decontamination-equipment-decision-offers-Smiths--75-million/index.asp>

¹⁴⁴ <http://www.eod.navy.mil/whatwedo.htm>

¹⁴⁵ <http://www.nationaldefensemagazine.org/issues/2003/Jun/Decontamination.htm>

¹⁴⁶ http://www.ecbc.army.mil/ip/annual_report/ecbc_2004_annual_report.pdf

¹⁴⁷ http://www.ecbc.army.mil/ip/annual_report/ecbc_2004_annual_report.pdf

¹⁴⁸ http://www.epa.gov/sab/pdf/homeland_security_presidential_directives.pdf.

F. Operations Center

1. This TEU will use the Operations Center for access to experts in the field as necessary.
2. Communications will be open with the Operations Center at all times in order to share data and receive updates as necessary on the identification and decontamination of the ship, as affects this TEU.

G. Similar Projects

1. Edgewood Chemical Biological Center has been working for some time on developing materials and equipment for sensitive decontamination.¹⁴⁹
2. The JSSED (Joint Services Sensitive Equipment Decontamination) is a program used across the DOD by U.S. Army, U.S. Navy, U.S. Air Force, and U.S. Marine Corps to decontaminate sensitive objects. They have worked closely with Edgewood to develop non-aqueous and non-caustic decontaminants.¹⁵⁰
3. The Battelle team, at request of the DOD, has also worked on creating a modular decontamination system for sensitive equipment. Their system used modified commercial decontaminants placed in a specialized environment that decontaminates the object and then removes both contaminant and decontaminant.¹⁵¹

¹⁴⁹ <http://www.dps.state.vt.us/cjs/mcl.html>

¹⁵⁰ http://www.jpeocbd.osd.mil/page_manager.asp?pg=2&sub=15

¹⁵¹ http://nationalsecurity.battelle.org/clients/inno_related.aspx?id=44

Specifications for Robotics Module

A. Overview

This TEU will store exploratory robots to be used to safely investigate contaminated spaces and potentially collect samples without placing personnel in danger. The module will also be able to handle the returned robots, storing them safely until they can be decontaminated as well.

B. Personnel

1. Personnel will consist of technicians who have been trained in the maintenance and usage of the robots used. Decontamination of the robots themselves will mostly be handled by the Sensitive Equipment Decontamination TEU, but some experience with CBRN handling and decontamination is necessary, especially when handling samples of the contaminant. As the robots will be field-programmable, personnel should have training in the chosen programming language and debugging techniques.
2. Primary technicians should be an ET rating who has completed at least “A” school training. These individuals will be responsible for maintaining and controlling their robots, guiding them on reconnaissance missions and retrieving the samples, if their robot is equipped to do so.¹⁵²
 - a) The ET will also be responsible for any field programming necessary.
 - b) While the ET will not decontaminate the robot, they are responsible for making sure that each robot is fully decontaminated by the end of the mission, and in good working order for the next.
3. ET’s will also be able to reach Information Systems Technicians in the event of communications issues between the robot and controller, and advanced technical issues.¹⁵³
4. Equivalent civilian jobs to the ET rating include electronics technicians, electronic equipment repairers, data communications technicians and electronics mechanics.¹⁵⁴ In addition to these in-demand jobs, the technicians assigned to this TEU will gain experience and knowledge in working with robotics.

C. Equipment

1. The TEU will need power access, storage capabilities and environmental controls.
2. The TEU itself will store the robots used on reconnaissance missions.
3. Ideally, one robot would be able to handle all required duties including reconnaissance, sample collection, and planning the navigation of the contaminated ship.
 - a) Required (or industry-standard) in the design of the robot would be:

¹⁵² <http://www.cnrc.navy.mil/factsheets/AECF.pdf>

¹⁵³ <http://usmilitary.about.com/od/enlistedjob1/a/it.htm>

¹⁵⁴ <http://www.cnrc.navy.mil/factsheets/AECF.pdf>

- 1) Ability to withstand temperatures between 40 and 120 degrees Fahrenheit.
- 2) Ability to run for 2 to 4.5 hours at a time without recharging.
- 3) A monthly maintenance time of .5 to 2 hours.
- 4) An annual maintenance cost of \$300-\$500 (this is aside from costs of CBRN decontamination)
- 5) A top speed of 5 kph.
- 6) Weighing 59 kg or less
- 7) An LED light with a camera
- 8) Multiple firing circuits.
- 9) Waterproof
- 10) Ability to traverse uneven surfaces, including standard 8-inch commercial stairs.
- 11) .75 inch cleats to provide traction

b) Ideal additions to the design:

- 1) USB joystick-controlled, or a similar control device
- 2) A retractable, multi-jointed arm that allows a mounted camera or a sample container.
- 3) Field-programmable
- 4) Modular design with a small footprint.
- 5) Increase top speed to 10kph
- 6) Decrease weight to 24 kg
- 7) Ability to move from floor to walls and traverse vertical surfaces.
- 8) Autonomous navigation in addition to remote control.

D. Environmental Considerations

1. Robots should be hardy enough to withstand the effects of rough seas.
 - a) Similar to Apple's Sudden Motion Sensor, the hard drive head should instantly park if unusually high vibrations, a sudden change in position, or sudden, unexpected acceleration is detected. This will protect the hard drive on the robot, as well as any data that it has stored, while allowing the hard drive to start up again almost instantly.¹⁵⁵
 - b) Another solution, although one that is far more expensive, is to use a solid-state drive that does not have the vulnerable moving parts that a traditional drive does.¹⁵⁶
2. Only clean robots will be stored in the TEU.
 - a) When the mission is complete, the controller should maneuver the robot into a secure container in which it can be transported to the Sensitive Equipment Decontamination TEU, its samples collected and sent off for analysis, and the robot decontaminated for another mission or to be returned to storage. This will eliminate the possibility of this unit's personnel being exposed to contaminants.

¹⁵⁵ <http://docs.info.apple.com/article.html?artnum=300781>

¹⁵⁶ [http://www.sandisk.com/OEM/ProductCatalog\(1274\)-SanDisk_SSD_Solid_State_Drives.aspx](http://www.sandisk.com/OEM/ProductCatalog(1274)-SanDisk_SSD_Solid_State_Drives.aspx)

E. Operations Center

1. This module will need access to the secured network for communication with onshore personnel about the robot's findings.

F. Similar Projects

1. iRobot PackBot EOD

- a) Selected by Edgewood as the premier CBRN detection robot due to its wide array of sensor capabilities.¹⁵⁷
- b) Notable for being lightweight (less than 24 kg), with a deployment time of less than 2 minutes, all-weather and all-terrain and with a manipulator arm that has multiple articulation points.¹⁵⁸
- c) Operator interface is an all-weather keyboard with integrated mouse and two multi-degree-of-freedom controllers.¹⁵⁹
- d) Unit is designed to deal with a wide variety of Improvised Explosive Device (IED), HAZMAT, EOD and conventional ordnance missions.¹⁶⁰

2. ASENDRO¹⁶¹

- a) Developed robots specifically for EOD
- b) Has autonomous controls as well as the ability to be remotely controlled.
- c) Unique in that the cameras are stereo, resulting in a 3-d image.

3. Allen Vanguard

- a) Developed the Vanguard ROV¹⁶²
 - 1) Ascends and descends stairs.
 - 2) Unique component is an integrated RS232 port for CBRN sensor devices.

4. Vortex VRAM¹⁶³

- a) Brand-new technology allows the robot to climb walls and move from the floor to the wall and back again.
- b) Has a single joystick and allows field programmability

¹⁵⁷ http://findarticles.com/p/articles/mi_m0EIN/is_2006_June_26/ai_n16498604

¹⁵⁸ <http://www.irobot.com/sp.cfm?pageid=165>

¹⁵⁹ http://www.irobot.com/filelibrary/GIspecsheets/iRobot_PackBot_EOD.pdf

¹⁶⁰ <http://www.irobot.com/sp.cfm?pageid=138>

¹⁶¹ <http://www.asendro.de/index.php?id=110&L=1>

¹⁶² <http://www.allen-vanguard.com/Catalogue/RO/555/909403.html>

¹⁶³ <http://www.vortexhc.com/vmrp.html>

Specifications for CDC Module

A. Overview

This module will be provide office and lab space for CDC personnel. The CDC will help identify contaminants, assess dangers, assist in creating a strategy and action plan, provide information to personnel on safety at the site, train other personnel as needed, and provide technical assistance to decontamination efforts and evaluation processes. If necessary, they will also test personnel for contamination.¹⁶⁴

B. Personnel

Personnel will be made up of employees of the CDC, to include an emergency response specialist¹⁶⁵ and a health scientist¹⁶⁶ trained in emergency preparedness and response.

C. Equipment

1. Standard office equipment – allow CDC employees to access key databases including Pulsenet, a surveillance system that lets labs exchange information about bacteria using DNA fingerprints.¹⁶⁷ Scanners are key in transmitting results to CDC colleagues and other partners onshore.¹⁶⁸
2. The Laboratory Response Network for bioterrorism has four levels: A, B, C, and D. The lab on the platform/transport vessel is envisioned to be a Level D laboratory with the “highest level containment and expertise in the diagnosis of rare and dangerous biological agents.” Level D laboratories can also have a strain bank of biological agents. They have the capacity to perform advanced diagnostic technologies and tests.¹⁶⁹
3. In terms of equipment, the lab component will be similar to the General Laboratory Module. Equipment should be durable; breakable materials such as glass should be avoided.¹⁷⁰ Safety features such as biological medical cabinets are important.¹⁷¹ Features should include climate control, counter space, sink and sample prep areas, freezer space, and seawater and compressed air connections.¹⁷²

D. Environmental Considerations

¹⁶⁴ <http://www.bt.cdc.gov/radiation/cdcrole.asp>

¹⁶⁵ <http://www.cdc.gov/employment/topjobs.htm>

¹⁶⁶ <http://www.cdc.gov/employment/topjobs.htm>

¹⁶⁷ <http://www.cdc.gov/about/stateofcdc/cdrom/SOCDC/SOCDC2006.pdf>

¹⁶⁸ <http://www.cdc.gov/print.do?url=http://www.bt.cdc.gov/agent/anthrax/webcast/110901/anthrax-webcast-transcript110901--3of9.asp>

¹⁶⁹ <http://www.cdc.gov/print.do?url=http://www.bt.cdc.gov/agent/anthrax/webcast/110901/anthrax-webcast-transcript110901--3of9.asp>

¹⁷⁰ <http://www.who.int/csr/resources/publications/biosafety/Biosafety7.pdf>

¹⁷¹ <http://www.who.int/csr/resources/publications/biosafety/Biosafety7.pdf>

¹⁷² From General Lab Module write-up

1. Standard maritime technology and techniques should ameliorate most issues that might arise. Technicians may need training specifically in working in a laboratory environment aboard a ship.¹⁷³
 2. It is likely that the platform/transport vessel will arrive well after the events that caused the contamination, minimizing the effect of the wartime or meteorological events on the ship.¹⁷⁴ However, neutralizing the effects of high seas and/or wartime issues will be taken into account in the design of the ship.
- E. Agency Partnerships
1. The CDC will work with the USN throughout the investigation.
 2. CDC personnel onboard will work with colleagues onshore, who will build on partnerships already established:
 - a) CDC partners with NIH on developing vaccines¹⁷⁵
 - b) CDC partners with the FBI at an organizational level through the Association of Public Health Laboratories (APHL)¹⁷⁶
 - c) CDC partners with the EPA, with the Nuclear Regulatory Commission (NRC), with the Department of Homeland Security, and with other agencies within HHS including the FDA.¹⁷⁷
- F. Operations Center
1. The CDC module may partner with the Operations Center to report data findings, but they will work primarily with CDC colleagues.¹⁷⁸
- G. Similar Projects
1. The CDC has “developed an effective way to rapidly test methamphetamine contamination to be used by law enforcement to detect if police officers seizing illegal meth labs have experienced a toxic exposure.”¹⁷⁹
 2. The CDC has developed an international team called the Global Disease Detection Program, or GDD. In 2006, the GDD responded to an outbreak of avian influenza in Nigeria. Two GDD lab scientists and one epidemiologist did lab work to assess the situation, and two other GDD staff worked with local authorities to implement surveillance and control activities. The CDC partnered with GDD to train local public health officials on diagnostics, response, and containment.¹⁸⁰

¹⁷³ From the FBI TEU write-up

¹⁷⁴ From the FBI TEU write-up

¹⁷⁵ <http://www.cdc.gov/about/stateofcdc/cdrom/SOCDC/SOCDC2006.pdf>

¹⁷⁶ http://www.aphl.org/programs/emergency_preparedness/Pages/default.aspx

¹⁷⁷ <http://www.bt.cdc.gov/radiation/cdcrole.asp>

¹⁷⁸ From the FBI TEU write-up

¹⁷⁹ <http://www.cdc.gov/about/stateofcdc/cdrom/SOCDC/SOCDC2006.pdf>

¹⁸⁰ <http://www.cdc.gov/about/stateofcdc/cdrom/SOCDC/SOCDC2006.pdf>

Specifications for Coast Guard Module

A. Overview

This module will allow the US Coast Guard to be physically present on the platform/transport vessel, so as to better work with the Navy on decontamination efforts. While the USCG has been involved in CBRN decontamination efforts in the past¹⁸¹, this module will primarily serve as office space and a communications center allowing Coast Guard personnel to relay information between the ship and the USCG.

B. Personnel

1. This module will have office space for between two and four persons. These should be USCG personnel with training and, ideally, experience in CBRN events.
2. If the CBRN event takes place in littoral areas, or otherwise falls under the USCG's physical jurisdiction, is likely that there will be ships and/or helicopters in the area that will need to be able to work with Navy personnel¹⁸². The persons assigned to this module may need to act as liaison between the two groups, as well as DHS and local civilians, in order to fulfill their missions of maritime security and national defense¹⁸³.

C. Equipment

1. The module will contain desk space for two people, with the option to expand as more personnel are brought onboard. There will also be a setup to retain communication with the USCG, most likely a radio transmitter/receiver. The module will consist of office space, but the basic design should be flexible enough to take on additional personnel and equipment as needed.

D. Environmental Considerations

1. Standard maritime measures will be taken to both fasten the TEU to the ship, and to keep its contents from being jarred in inclement environments.

E. Agency Partnerships

1. Department of Homeland Security (DHS)¹⁸⁴
 - a) Since the creation of DHS, the Coast Guard has been placed under their guidance, protecting littoral areas from terrorist threats. As a result of this, the Coast Guard provides a valuable link with DHS personnel and resources.
2. Local civilian government
 - a) As a part of DHS, the Coast Guard is experienced in working with local government personnel in affected areas.

¹⁸¹ http://proceedings.ndia.org/5460/5460/1_hooper.pdf

¹⁸² Ibid.

¹⁸³ <http://www.uscg.mil/top/missions/>

¹⁸⁴ <http://www.cnn.com/2003/ALLPOLITICS/02/25/homeland.security/index.html>

3. Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD)¹⁸⁵

- a) “The Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) is the principal advocate and single point of contact for all chemical, biological, nuclear and radiological detection, and vaccine and medical diagnostic acquisition efforts within the scope of the JPEO-CBD charter.”
- b) Under the Joint Task Force Civil Support (USNORTHCOM), the Coast Guard works with the JPEO-CBD in order to research and implement protection and decontamination of chemical and biological agents.¹⁸⁶ JPEO-CBD is particularly interested in discouraging biological warfare.

F. Operations Center

It is unlikely that the Coast Guard will need to rely heavily on the Operations Center. A connection to the ship/OC intranet should be sufficient, as personnel in this module will primarily report to USCG officers.

G. Similar Projects

1. The USCG and the Navy have worked together since before WWI. Notably, during WWII, several Naval transport vessels (among other sea craft) were staffed by Coast Guard personnel.¹⁸⁷
2. The Navy and the USCG have joined forces before in issues of Homeland Security, specifically under OPERATION NOBLE EAGLE.¹⁸⁸ Under this mission, Naval ships were employed jointly with Coast Guard forces to monitor the Gulf and East Coast areas.

¹⁸⁵ <http://www.jpeocbd.osd.mil/>

¹⁸⁶ <http://www.jtfcs.northcom.mil/pages/news20030425.html>

¹⁸⁷ http://www.uscg.mil/history/h_cgnvy.html

¹⁸⁸ <http://c21.maxwell.af.mil/maritime/navyuscg.htm>

Specifications for EPA Module

A. Overview

This module will provide office and analytic laboratory space to employees of the EPA in order to further their ability to research CBRN contamination prevention. The EPA is primarily concerned with the health of both humans and the environment, and thus has a stake in contaminants that can affect both the population of a ship and the environment around that ship.¹⁸⁹

B. Personnel

1. Office and laboratory space should allow for two to three employees to use the module.
2. Employees should receive training and have a background in CBRN events and working with contaminants in a safe manner.

C. Equipment

1. This module will be set up as a standard office module with some adjustments as needed.
2. Part of the module should be able to be turned into a laboratory with standard testing equipment, so that the EPA can conduct tests if it becomes necessary.

D. Environmental Considerations

1. Standard precautions should be taken for working in a marine environment. Office equipment should be secured, and any smaller supplies should be safely stored away to prevent any damage.
2. The laboratory will be separated from the office portion by a secure partition and door, and should have its own entrance, to reduce the possibility of introducing contamination to the office. Due to these requirements, the EPA TEU may require a forty-foot container.

E. Agency Partnerships

1. Department of Homeland Security
 - a) The EPA has been specifically tasked with monitoring drinking-water and water-treatment systems by DHS. They are also tasked with surveying CBRN laboratories “standards, protocols, & capabilities to address the risks of contamination following a biological weapons attack & developing strategies, guidelines, & plans for decontamination of persons, equipment, & facilities.”¹⁹⁰
2. Food and Drug Administration
 - a) Due to overlap in their duties, the FDA and EPA often overlap, particularly when it comes to environmental effects on human populations,

¹⁸⁹ <http://www.epa.gov/epahome/aboutepa.htm#mission>

¹⁹⁰ http://www.epa.gov/sab/pdf/homeland_security_presidential_directives.pdf

as with mercury in fish¹⁹¹. As explained in the FDA module description, the effects of a CBRN event may require input from both agencies.

3. Center for Disease Control (CDC)

a) As with the FDA, often the EPA's interests overlap with the CDC when disease and environmental factors come together¹⁹². Notably, they worked together post-Katrina to address contamination concerns in floodwater.¹⁹³

F. Operations Center

The module will have a connection to the Operations Center through the intranet, but will primarily report back to the EPA.

G. Similar Projects

1. EPA guidelines have routinely been used in developing protective equipment to be used in CBRN situations, such as the CBRN Powered Air Purifying Respirator (PAPR) Standard.¹⁹⁴
2. The EPA has specifically been singled out and applauded by the Chemical and Biological Defense Information Analysis Center (CBIAC) for their work in protecting and maintaining safe drinking water, specifically from CBRN threats.¹⁹⁵

¹⁹¹ <http://www.cfsan.fda.gov/~dms/admehg3.html>

¹⁹² <http://www.epa.gov/pesticides/health/mosquitoes/mosquitojoint.htm>

¹⁹³ <http://yosemite.epa.gov/opa/admpress.nsf/d035c490ea7b4166852572a000658ee9/43426907350a956a8525707500675088!OpenDocument>

¹⁹⁴ <http://www.cdc.gov/niosh/npptl/standardsdev/cbrn/papr/concepts/paprcon-020604.html>

¹⁹⁵ http://www.cbrniac.apgea.army.mil/products/newsletter_pdfs/vol7_num2.pdf

Specifications for FDA Module

A. Overview

This module will provide office space and connectivity to FDA employees who are assigned to accompany the platform/transport vessel out into the field. Employees will have access to the data on the contaminated ship so that they can keep in contact with FDA land offices, and fulfill their mission statement of protecting the public's health¹⁹⁶.

B. Personnel

1. Space in the module will allow for desk space for two or three employees. These employees will share living quarters with Navy personnel, and have access to the intranet, allowing them to communicate with experts on land if necessary.
2. Employees should have received training in proper responses to CBRN events, and have some connection to the National Center for Toxicological Research (NCTR).¹⁹⁷

C. Equipment

1. This module will be set up as a standard office module with some adjustments as needed.
2. Following the FDA's pattern of developing treatments for bioterrorist agents, part of the module should have the ability to become a laboratory with standard testing equipment, so that the FDA can conduct their own tests if it becomes necessary.¹⁹⁸

D. Environmental Considerations

1. Standard precautions should be taken for working in a marine environment. Office equipment should be secured, and any smaller supplies should be safely stored away to prevent any damage.
2. If the module will act as a laboratory, additional precautions should be taken to prevent contaminants from spreading. (This may necessitate breaking this module out into two connected TEUs, one dedicated to office space and the other to a research laboratory.)

E. Agency Partnerships

1. Center for Disease Control (CDC)
 - a) The FDA and CDC have historically worked closely on issues of disease prevention and eradication.
 - 1) Response to and prevention of Severe Acute Respiratory Syndrome (SARS) transmission¹⁹⁹
 - 2) Blood donation purity issues²⁰⁰

¹⁹⁶ <http://www.fda.gov/opacom/morechoices/mission.html>

¹⁹⁷ <http://www.fda.gov/nctr/>

¹⁹⁸ <http://www.fda.gov/nctr/initiatives/initiatives.htm#Bioterrorism>

¹⁹⁹ http://findarticles.com/p/articles/mi_m3225/is_10_67/ai_102223782

2. Pine Bluff Arsenal

a) The NCTR is physically located near the Army Pine Bluff Arsenal, and has historically worked closely with the armed forces.²⁰¹

3. Department of Health and Human Services (DHHS)

a) DHHS has also become concerned with CBRN WMDs and their possible use against civilian populations. They have worked with the FDA to develop and stockpile treatments for these agents.²⁰²

F. Operations Center

The module will have a connection to the Operations Center through the intranet, but will primarily report back to the FDA.

G. Similar Projects

1. The FDA primarily protects food products, cosmetics, and licenses drugs.
2. Due to this, the only overlap between the FDA and at-sea decontamination ops would likely involve compromised food supplies.
3. On the personnel side, the FDA may also have a role, as they have developed drugs (such as ciprofloxacin²⁰³) for treatment of bioterrorism agents. Their presence on the ship may lead to increased chances for real-world research and development of treatments.

²⁰⁰ <http://www.fda.gov/cber/infosheets/tickborne2.htm>

²⁰¹ <http://www.fda.gov/nctr/initiatives/initiatives.htm#Bioterrorism>

²⁰² <http://www.asanltr.com/newsletter/07-2/articles/072c.htm>

²⁰³ http://www.fda.gov/fdac/features/2004/104_terror.html

Specifications for FBI Module

A. Overview

1. This module will provide office and crime scene investigation space for FBI personnel.
 - a) It is estimated that this module will be necessary for all CBRN events that occur in US waters and many out-of-country as well.
2. At time of writing, only one module is planned. If necessary, this TEU may be broken out into two; one to act as an office and the other to act as a CSI lab.

B. Personnel

1. Personnel will be made up of employees of the FBI.
 - a) At least one member, if not all employees assigned to this module, will be part of the Hazardous Materials Response Unit²⁰⁴. These persons will have received training and have experience in CBRN events.
2. Space will likely allow for 2-3 personnel per TEU.²⁰⁵

C. Equipment

1. Standard office equipment (computer, desk, etc.)
 - a) This will allow the FBI to fulfill the intelligence-gathering aspects of their job.²⁰⁶
 - b) Communication will occur over the network with both the operations center and FBI headquarters/Quantico as needed.
2. The CSI compartment of the TEU will be similar to the General Laboratory Module, to be used for storing and analyzing collected materials before decontamination takes place. Some specialized containment may be necessary, but the focus of the laboratory will be less on finding the proper decontamination procedure.²⁰⁷

D. Environmental Considerations

1. Standard maritime technology and techniques should ameliorate most issues that might arise. Technicians may need training specifically in working in a laboratory environment aboard a ship.²⁰⁸

E. Agency Partnerships

1. It is expected that the FBI will work closely with the Navy throughout the investigation.
2. As with the Navy, the FBI will likely liaise with the EPA and CDC in order to collect information or share findings throughout the investigation and decontamination of the CBRN event. The majority of crime scenes the FBI

²⁰⁴ <http://www.fbi.gov/hq/lab/org/hmru.htm>

²⁰⁵ <http://www.newagelandmark.com/labs.html>

²⁰⁶ <http://www.fbi.gov/congress/congress07/mueller011107.htm>

²⁰⁷ <http://www.fbi.gov/hq/lab/fsc/backissu/april2000/twgcsi.pdf>

²⁰⁸ <http://www.moc.noaa.gov/rb/science/labs.htm#labsurface>

investigates are not CBRN events, and they will likely need to quickly gather information on these unique scenes, despite the specialized knowledge of the technicians.²⁰⁹

F. Operations Center

1. The FBI module may contact the Operations Center to report data found, but it is likely that they will mostly work directly with FBI personnel.

G. Similar Projects

1. This modular laboratory is similar both to the FBI Hazardous Materials Response Unit²¹⁰ and to many of the aspects of the FBI Laboratory.²¹¹
2. Mobile CSI units have been produced before.
 - a) In the UK by the Forensic Science Services (an executive agency of the Home Office), a mobile CSI van was debuted in 2005 in order to speed the processing of evidence at crime scenes and thus deliver intelligence more quickly.²¹²
 - b) Vermont has had an active mobile crime laboratory since the mid-fifties, equipped to respond to and process the crime scene.²¹³

²⁰⁹ <http://www.fbi.gov/hq/lab/org/hmru.htm>

²¹⁰ Ibid.

²¹¹ <http://www.fbi.gov/hq/lab/labhome.htm>

²¹² <http://networks.silicon.com/mobile/0,39024665,39130383,00.htm>

²¹³ <http://www.dps.state.vt.us/cjs/mcl.html>

Specifications for Datacenter Module

A. Overview

The datacenter supports the Information Technology (IT) needs of the other TEU modules by hosting the servers, storing the data, and providing the technological capacity to perform any large tasks sent from the other modules. In addition, the datacenter includes backup power supply and backup data storage to minimize disruption and loss if something should fail.

B. Personnel

1. Navy Cryptologic Technicians²¹⁴ - includes Cryptologic Technician (Communications)²¹⁵, Cryptologic Technician (Maintenance)²¹⁶ and Cryptologic Technician (Administration)²¹⁷ ratings – coordinate, administer, and maintain networks. Expertise in/attention to redundancy of data and function, efficiency and rapid processing, and standard navy protocols for data transmission, handling, and security
2. Electronics Technician²¹⁸ - maintain and repair electronics equipment
3. Interior Communicationman²¹⁹ - install and maintain interior communications systems including telephones and audio-visual equipment
4. Information Systems Technician²²⁰ - manage IP, LANs, software installation:
 - a) Manager(s) for Windows
 - b) Manager(s) for Linux/Unix
 - c) Manager(s) for other operating systems, as needed
5. Equivalent civilian positions are in high demand, particularly for systems administrators.

C. Equipment

1. The datacenter TEU must contain:
 - Servers (primary & backup)²²¹
 - Computing and network infrastructure
 - Network security elements
 - Network Operations Center – a monitoring system
 - Environmental control systems – HVAC
 - Fire prevention & suppression systems
 - Power distribution and redundant power system
 - Circuit breaker protection
 - Redundant data communications

²¹⁴ <http://usmilitary.about.com/cs/navy/a/navyctn.htm>

²¹⁵ <http://usmilitary.about.com/od/enlistedjob1/a/ctm.htm>

²¹⁶ <http://usmilitary.about.com/od/enlistedjob1/a/cta.htm>

²¹⁷ <http://usmilitary.about.com/od/enlistedjob1/a/cta.htm>

²¹⁸ <http://usmilitary.about.com/od/enlistedjob1/a/et.htm>

²¹⁹ <http://usmilitary.about.com/od/enlistedjob1/a/ic.htm>

²²⁰ <http://www.usarec.army.mil/hq/warrant/prerequ/wo251A.html>

²²¹ <http://www.moc.noaa.gov/rb/science/equipment.htm>

- Lighting²²²

The datacenter must have machines with the capacity to perform large tasks – including modeling, supporting the C⁴I/O TEU, etc. The datacenter should be virtualized in order to increase flexibility. Virtualization is a means of running multiple operating systems on one machine through use of software that makes each operating system act as if it had its own hardware. While the software uses some space, virtualization increases flexibility since operating systems can easily be added and deleted, and space used to support one can be repurposed to support another.

D. Environmental Considerations

1. Since the datacenter must be able to perform well in any situation as well as in a period of change, flexibility and robustness are key. Security of data is also very important, and encryption systems need to be considered in addition to the measures taken to protect the physical security of the TEU.²²³
2. To the extent possible, measures must be taken to minimize the risk of damage or disruption. For example, machines could be welded to the walls. All cables should be duplicated so that if one fails, a machine can switch to backup immediately and automatically alert the staff to the problem.

E. Agency Partnerships

1. There should be no need to work with non-Navy agencies.

F. Operations Center

1. If we set up a VPN or other encryption with strong access to the network, many of the IT staff can work remotely. At least one hardware engineer should be onsite in order to ensure that all disruptions can be fixed as quickly as possible. Remote staff would not be exposed to hazardous contaminants, which could reduce personnel costs. However, transmitting data remotely requires very strong security and encryption.
2. Information systems technicians could be remote if there were in-band remote access to the network. In-band access refers to access through the network itself, such as a VPN.
3. Navy cryptology technicians, electronic technicians, and interior communicationmen would need to be onsite in the beginning, but if strong out-of-band access were available, most of them could leave and work remotely once everything was set up. Out-of-band access allows access to the network in such a way that staff can retain their connection even while modifying the network. For example, out-of-band access can be set up through a modem.

G. Similar Projects

1. Sun Microsystems has pioneered the development of a datacenter in a shipping container.

²²² http://www.siemon.com/us/white_papers/03-10-10-data_centers.asp?source=cnet

²²³ <http://www.objs.com/workshops/ws9801/papers/paper085.html>

- a) Called Project Blackbox, is designed to be easily portable and efficient in its use of energy and space.
 - b) Project Blackbox only requires three external resources: water²²⁴, AC power, and networking.²²⁵ We would need to account for these three resources on the ACS.
 - c) Project Blackbox incorporates design elements to allow the containers to be transported without damage; these should be confirmed and/or tested for stability in the ocean.
2. Rackable has already made at least one sale of a datacenter in a 40-foot TEU.²²⁶

²²⁴Sun Microsystems has designed an innovative cooling system that contributes to the efficiency of Project Blackbox. A panel of heat exchangers sits between each set of racks. A water-based cooling system with fans circulates cool air and extracts excess heat, reducing power consumption and allowing the datacenter to function without air conditioning. *Project Blackbox Interactive Tour* online at <http://www.sun.com/emrkt/blackbox/index.jsp>

²²⁵<http://www.sun.com/emrkt/blackbox/index.jsp>

²²⁶http://www.datacenterknowledge.com/archives/2007/Mar/30/rackable_selling_portable_data_center.html

Specifications for Media Module

A. Overview

The Media Module is a fully equipped press filing center. It has all the capacities that would be found at a filing center at a major trade conference or sporting event. It is intended to accommodate a Naval Public Affairs Officer and 2-3 media teams that each consist of a major media reporter (TV/Radio), a producer and technician.

B. Personnel

1. Naval Public Affairs Officer (Lieutenant, O-3 or above)
 - a) Training- should be trained in dealing with media during highly sensitive incidents.
2. The Army has a classification of a Media Relations Officer²²⁷
3. The Marine Corps lists the training a Public Affairs Officer gets in dealing with the media in MCO 1510.62²²⁸
4. Equivalent civilian title would be Press Secretary or Communications Director

C. Equipment

1. 4-5 ISDN Phone lines
2. 802.11b wireless internet connection
3. Broadcast Media Mult Box
4. 4-5 Video Monitors
5. Electric Outlets (110 amp)
6. Capability for either Satellite or Microwave transmission
7. Backup power supply for all equipment
8. Lighting
9. Fire Prevention and Suppression systems
10. Power Distribution and redundancy systems
11. Environmental Control Systems- HVAC

D. Environmental Considerations

1. Exterior
 - a) Shipping containers are specifically designed for maritime transportation and therefore are resistant to such dangers as waves, rain, high winds and fire.²²⁹
 - b) Media module will be fully-insulated to protect against damage to equipment during extreme weather conditions.
2. All interior fixtures will be secured to prevent tipping during time at rough seas.

²²⁷ <http://usmilitary.about.com/library/milinfo/aroffjobs/blpa.htm>

²²⁸ <http://usmilitary.about.com/gi/dynamic/offsite.htm?site=http://www.usmc.mil/directiv.nsf/df51342d91236d2685256517004eb026/29b8452aaf494844852568cc0060d779%3FOpenDocument>

²²⁹ http://www.bobvila.com/HowTo_Library/Converting_Shipping_Containers_for_Housing-Building_Systems-A2382.html

E. Agency Partnerships

The Naval Public Affairs Officer will work closely with the DHS Office of Public Affairs²³⁰ and other government press offices as appropriate.

F. Operations Center

The Naval Public Affairs Officer aboard the ship will work closely with the other Public Affairs Officers in the Operations Center to get updates on the status of supporting activities and ensure that they are conveying “one voice” to members of the media.

G. Similar Projects

The Navy has dealt with the media in the following recent CBRN events:

- a) USS Hartford, 2003²³¹
- b) USS Oklahoma City, 2002²³²
- c) USS Cole, 2000²³³

²³⁰ <http://www.dhs.gov/xnews/contacts/>

²³¹ http://findarticles.com/p/articles/mi_qn4158/is_20031113/ai_n12732473

²³² http://findarticles.com/p/articles/mi_pnav/is_200212/ai_3520898847

²³³ <http://www.defenselink.mil/releases/release.aspx?releaseid=2814>

Specifications for General Office Module

A. Overview

The General Office Module is a mobile unit providing managerial personnel with private office space and a location for small meetings. With several configuration options, the General Office Module is prepared to accommodate differing numbers of personnel and their needs. This TEU will be used throughout the duration of the decontamination process for all organizational and managerial tasks

B. Layout

1. Two private office spaces will be sectioned off at either end of the TEU.²³⁴
 - a) Each office will be equipped with two personal desks and accompanying chairs.²³⁵
 - 1) Built-in filing cabinets and bookcases will be available at each desk area.
 - 2) Each desk will come equipped with a laptop docking port and printer.
 - 3) All personal desks and desk accessories will be constructed out of lightweight metal.
2. The center TEU section will be a meeting area consisting of one long table with seating for eight
 - a) The table and all chairs can be folded to convert the meeting area into an all-purpose room for small groups.
3. One large closet in the meeting area will be used for storing all office and cleaning supplies.
4. A power generator will supply electricity for all computer accessories and lighting.

C. Environmental Considerations

1. Due to its mainly administrative purpose, the General Office Module will likely avoid contact with hazardous material and contaminated personnel.
 - a) The inside of the General Office Module should be easily decontaminated in the event of exposure to CBRN agents.
2. Desks are built into the TEU walls to avoid shifting during transportation and rough seas.
3. All office supplies must be kept in closed, secure containers when not in use in order to prevent spilling.

D. Operations Center

²³⁴ http://www.mobileofficeinc.com/floor_50x10.html

²³⁵ <http://www.nationalonline.com/nof-desks/envyworks.htm?applicationid=4>

1. Personnel using the General Office Module can stay in constant contact with the Operations Center via computer.
 - a) What information will be relayed between the General Office Module and the onshore OC depends on which container ship personnel use the personal office space.
2. Video conferencing can be made available in the meeting area to connect personnel in the Operations Center with shipboard meetings.²³⁶

E. Similar Projects

1. SCIF Solutions, Inc.²³⁷
 - a) Founded by a U.S. Navy veteran, SCIF has developed a mobile office trailer well-suited for rapid deployment to disaster and emergency sites, including military-related incidents.
 - b) The Office Trailer SCIF can be used as a model for the General Office Module's construction and technical configuration.
2. Odd Cubes²³⁸
 - a) The Office Container constructed by Odd Cubes comes complete with wall insulation, a ventilation fan, electrical wiring, and interior plumbing that can all be used as technical examples for the General Office Module.
3. Maristar²³⁹
 - a) China-based Maristar produces 20' stackable office containers with various interiors that can help in determining which equipment and furniture will be best for the General Office Module's use.

²³⁶ http://www.lifesize.com/products/lifesize_team/

²³⁷ http://www.scifsolutions.com/office_trailer_scif.html

²³⁸ http://www.oddcubes.com/office_container.html

²³⁹ <http://www.chinamaristar.com/products.htm>

Specifications for Mess Hall Module

A. Overview

This module will act as mess hall for all personnel stationed on the platform/transport vessel. Consisting of several TEUs, it will have a self-contained kitchen, storage area, and eating spaces (Officers' and Enlisted Mess), with personnel to prepare and serve food.

B. Personnel

1. Culinary Specialists²⁴⁰

- a) One or more CS ratings should be assigned to this module to prepare, serve and track food and food supplies.

C. Equipment

1. Within the kitchen TEU, standard cooking equipment will be used: stove, oven, sinks, etc. This TEU will have access to hot and cold potable water, as well as environmental systems that allow venting outside without bringing in possible contaminants. This TEU will double as a cleanup space after meals.
2. There will also be a 'larder TEU', providing space for food, tableware, and equipment storage in secure bins.
3. The Mess TEU itself will supply tables and chairs as well as other necessities for comfort.

D. Environmental Considerations

1. Standard maritime precautions should be taken to prevent spillage or breakage of materials.
2. TEUs will be modeled after already-existing Naval messes aboard ships.

E. Agency Partnerships

No agency partnerships expected.

F. Operations Center

This module will not need to communicate with the Operations Center.

G. Similar Projects

1. Konstructa

- a) Konstructa is a commercial business offering for-hire modular mess halls. Available in a variety of sizes, they are not standard-sized but offer some guidance in making modular kitchens and mess rooms.²⁴¹

2. Marine Rapid Deployment Kitchen and Field Sanitation Unit²⁴²

- a) A quickly set-up, modular on-site mess hall unit used by Marines, this Unit consists of three standard TEUs making up a kitchen and sanitation

²⁴⁰ http://buperscd.technology.navy.mil/bup_updt/508/OccStandards/CHAPTER%2054.htm

²⁴¹ <http://www.konstructa.co.uk/mess-rooms.html>

²⁴² <http://www.usmc.mil/marinelink/mcn2000.nsf/0/a9b51c9f3f3df0858525701900211d6c?OpenDocument>

unit. The FFSS is set up for large-scale use, feeding hundreds of Marines two hot meals a day.

3. Deployable Rapid Assembly (DRASH) Shelters²⁴³

a) Created by DHS Systems, these are quick-erect, durable shelter systems that can be configured in a variety of ways. Although intended primarily for medical personnel, they do allow for the creation of a mess hall.

²⁴³ http://www.alkanshelter.com/news/MMT_10_7.pdf

Specifications for Housing Module

A. Overview

The Housing Module is a simple solution to providing working personnel from both the contaminated vessel and the response vessels with private living quarters and all related accommodations. The modules' flexible design addresses the personal comfort and care of all personnel with spacious rooms and a high level of privacy. Each unit is well-suited to last for the duration of a maritime project.

B. Housing Unit Layout

1. A growing interest in the usage of shipping containers as housing structures has already produced numerous design possibilities to fit any amount of space and number of inhabitants.²⁴⁴
2. TEU containers will be stacked together into one large apartment-style complex encased by an easily assembled steel frame.²⁴⁵
3. One 40'x 8'x 8'6 container can be divided into several rooms to comfortably house two workers for an extended period of time.²⁴⁶
4. Accommodations include twin beds and bedroom furniture, storage space, and shared or private bathrooms, kitchens, and living space.

C. Required Utilities

1. Each housing unit should be equipped with the following:
 - a) Water access and drainage
 - b) Lighting and electricity
 - c) Air ventilation system
 - d) Climate control for heating and air conditioning
2. An installed loudspeaker system can be used in emergencies to alert personnel in all housing units.
3. A multi-level housing structure will provide all housing units with a shared utility system.

D. Environmental Considerations

1. Exterior
 - a) Shipping containers are specifically designed for maritime transportation and therefore are resistant to such dangers as waves, rain, high winds, and fire.²⁴⁷
 - b) Housing units will be fully-insulated to protect against extreme weather temperatures.
2. Interior

²⁴⁴ <http://www.fabprefab.com/fabfiles/containerbayhome.htm>

²⁴⁵ <http://www.containerliving.com/index.asp>

²⁴⁶ <http://www.tempohousing.com/products/manager.html>

²⁴⁷ http://www.bobvila.com/HowTo_Library/Converting_Shipping_Containers_for_Housing-Building_Systems-A2382.html

- a) Furniture may be bolted to the walls and floor to prevent tipping during rough seas.
- b) Safety handrails in showers and skid-resistant bathroom flooring will provide extra protection.

E. Similar Projects

1. Tempohousing by Keetwonen²⁴⁸
 - a) This Dutch firm offers fully-equipped housing units constructed from recycled shipping containers.
 - b) Multiple layout options are available, including welded-together containers accommodating twice as many inhabitants while providing a larger shared living space.
2. Urban Space Management Ltd²⁴⁹
 - c) The Container City system designed by USM utilizes recycled shipping containers to construct highly versatile modular buildings.
 - d) Several projects have already been completed in Great Britain and the United States, including live-in artist studio units, large children's centers, and classroom buildings.
 - e) Container Cities demonstrate the time and cost benefits of using shipping containers for housing while still keeping an aesthetically-pleasing exterior appearance and a comfortable interior living space.
3. Target Logistics²⁵⁰
 - a) Private and semi-private housing units are manufactured from TEU containers by Target Logistics.
 - b) The rapid deployment and easy setup of these units make them ideal for use in emergencies.

²⁴⁸ <http://www.tempohousing.com>

²⁴⁹ <http://www.containercity.com/home.html>

²⁵⁰ <http://www.targetlogistics.net/>

Specifications for First Aid Module

A. Overview

The First Aid Module is a mobile medical unit equipped to provide an array of health services and treatment options for all personnel working at the site of contamination. As the first line of treatment during the decontamination process, this TEU responds rapidly to both CBRN emergencies and everyday illnesses and accidents that may occur.

B. Personnel

- ^{1.} Hospital Corpsman Third Class (HM3)²⁵¹
 - a) Civilian equivalent of this position is a Registered Nurse (RN).²⁵²
2. Estimate two personnel per TEU.
3. Responsibilities include the following:
 - a) Perform preliminary assessment of and treat all foreseeable medical conditions
 - 1) External wounds and bodily injuries (including head, neck, and spine)
 - 2) Chemical intoxications, poisonings, and exposure to hazardous material
 - 3) Respiratory, cardiovascular, and gastrointestinal conditions
 - 4) General illnesses
 - 5) Infections
 - 6) Eye, ear, nose, and throat problems
 - 7) Dental emergencies
 - b) Prescribe and dispense medications
 - c) Dress and redress patients
 - d) Monitor vital signs
 - e) Determine when MEDEVAC support is necessary for critical conditions
 - f) Enter patient data into a computerized information system
 - g) Sterilize instruments and other materials
 - h) Inventory all medical equipment and supplies
 - i) Collect biomedical waste for removal
 - j) Prepare examining beds
4. Extensive first aid training and medical experience is required.
5. All personnel will wear Personal Protective Gear when examining and treating CBRN contaminated patients.

C. Layout

²⁵¹ http://buperscd.technology.navy.mil/bup_updt/508/OccStandards/CHAPTER%2040.htm

²⁵² <http://www.bls.gov/oco/ocos083.htm>

1. The First Aid Module will consist of two 40-foot TEU containers welded together lengthwise for maximum space utility.
2. The TEU will include the following sections:
 - a) One small waiting/intake area
 - b) One personnel office
 - c) One large medicine closet to hold all supplies²⁵³
 - 1) Hospital garments for patients
 - 2) Scrubs, gloves, and surgical face masks
 - 3) Diagnostic instruments
 - 4) Gauze, bandages, and other rehabilitation aids
 - 5) Sterilization equipment
 - 6) Medications
 - d) Two separate consultation rooms each with one examining bed and additional storage cabinets
3. Both examining rooms will have access to water and drainage for use when decontaminating patients exposed to hazardous material.²⁵⁴
4. The entire TEU will be well-lit and well-ventilated.
 - a) A generator will supply electricity for all lighting as well as for running all electric medical instruments and machines.
5. Climate control will regulate the TEU temperature for patient safety and comfort.

D. Environmental Considerations

1. Due to restocking limitations resulting from the maritime location of operation, the First Aid Module must be fully equipped to handle multiple cases of all foreseeable medical conditions.
2. Safety precautions such as non-slip floors and safety rails along the sides of examining beds will protect against injury during rough seas.
3. The medical supply closet and medical cabinets inside the examining rooms will have secured containers for supplies as well as safety locks on doors to protect against spilling.
4. The First Aid Module has the capability of decontaminating patients exposed to hazardous material in order to continue their treatment without threatening the stability of the TEU.

E. Operations Center

1. Computers will allow personnel from the First Aid Module to communicate at all times with the onshore Operations Center.
 - a) Up-to-date information on patients' conditions can be accessed by the OC personnel through the computerized information system.
2. Medevac operations will be coordinated by the bridge, which will link the First Aid Module personnel to the medevac and onshore hospital personnel.

²⁵³ <http://www.anandmedical.com/default.htm>

²⁵⁴ <http://www.bt.cdc.gov/planning/personalcleaningfacts.asp>

F. Agency Partnerships

1. Disaster Medical Assistance Teams²⁵⁵

a) A Disaster Medical Assistance Team (DMAT) is a group of professional medical personnel working under the U.S. Department of Health and Human Services.

b) With experience in rapid-response to disasters and other events, DMATs can assist the First Aid Module personnel in handling emergency situations.

2. American Red Cross²⁵⁶

a) Although not an official government agency, the American Red Cross coordinates with federal committees and provides services to the U.S. military.

b) With extensive experience in disaster relief and first aid, workers from the American Red Cross can instruct medical personnel on how to best provide health services while facing environmental constraints and limited resources.

G. Similar Projects

1. Normesca AS²⁵⁷

a) As a leading supplier of rapid response solutions for medical emergencies and disasters, Normesca AS has produced a range of mobile clinics and hospitals using tents, trailers, and containers.

b) The Container Hospital and other first aid modules demonstrate how to best configure the First Aid Module in preparation for both emergency and non-emergency medical situations.

2. Uniteam²⁵⁸

a) Uniteam's Mobile Hospital Units are ideal models for what medical equipment to include in the First Aid Module.

3. Vekkla²⁵⁹

a) Vekkla specializes in producing mobile expandable buildings constructed out of TEU containers.

b) The first aid containerized modules are specially constructed to be fully-transportable medical units requiring very little setup time.

²⁵⁵ <http://ndms.dhhs.gov/teams/dmat.html>

²⁵⁶ http://www.redcross.org/services/disaster/0,1082,0_319_,00.html

²⁵⁷ <http://www.normeca.no/normeca/index.htm>

²⁵⁸ <http://www.uniteam.org/shelter/mobilemedicalhospital.html>

²⁵⁹ <http://www.vekkla.com/Vekklacontainersystem.pdf>

Specifications for Airlock Module

A. Overview

This will be a purely functional module, dedicated to providing a space where personnel can safely move from the contaminated ship/environment to the network of TEUs without bringing contamination with them.

This module will be required for any personnel who may have been exposed to contaminants. Within the 'airlock', they can shed any HAZMAT gear that they have been wearing, and it will be safely collected for decontamination separately. The module will also contain shower systems so that personnel can completely clean themselves before returning to the TEU network.

The module will require access to water and power, have independent environmental controls and venting systems, and be carefully sealed and insulated against the outside environment. Due to the wide range of possible contaminants, it is particularly important that this module be configurable to respond to any situation.²⁶⁰

B. Personnel

No permanent personnel will need to be stationed in this module.

C. Equipment

1. Decontaminants

a) Working in tandem with the General Laboratory Modules, Airlock Modules will be supplied with skin decontaminants appropriate to the environment that personnel will have been working in.²⁶¹ Due to the variability in CBRN contaminants, the interior of the module will simply be lined with an inert material, with minimal environmental and comfort modifications.²⁶²

b) This module will also contain showers and appropriate clean clothing for personnel use.

2. Contaminated Materials Storage

a) The module will be able to safely get and store contaminated materials, including HAZMAT suits and any CBRN detecting and/or decontaminating equipment personnel may have with them.

3. Testing Equipment

a) After Personnel have shed contaminated clothes and equipment and cleaned up, they will be tested with handheld equipment for the presence of contaminants.²⁶³

²⁶⁰ <http://www.publichealth.thpct.nhs.uk/websiteadmin/uploads/S2d%20Response%20CBRN.pdf>

²⁶¹ http://www.ecbc.army.mil/ps/download/ECBC_m291.pdf

²⁶² <https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/22662-1/FM/3-11.5/chap9.htm>

²⁶³ https://portal.navfac.navy.mil/portal/page?_pageid=181,4723547,181_4723553&_dad=portal&_schema=PORTAL

D. Environmental Considerations

1. Taking into account the level of contaminants that may be in this module, and its proximity to living and working spaces, Airlock Modules will have an independent venting system, electrical backup, and environmental controls. A system of anterooms should ensure that personnel do not carry decontamination with them into the main network of modules.
2. Airlock Modules will be carefully sealed against the outside environment, and will have minimal changes made to the interior, taking advantage of the security of the TEU model. The Modules will be lined with an inert material that can easily be decontaminated if necessary.
3. Any storage in this module will have the ability to be both securely fastened down and easily moved to another module for decontamination.

E. Agency Partnerships

There is no need for liaisons with other agencies.

F. Operations Center

This module will not need to communicate with the Operations Center.

G. Similar Projects

1. Personal Decontamination Kits

- a) Multiple commercial personal decontamination kits exist, to be used in tandem with decontamination showers. These include a bagging system for personal effects, towels and other cleansing apparatus, and clean clothes to change into. They are generally targeted at civilian populations.²⁶⁴

2. Decontamination Showers

- a) Similar to the kits discussed above, there are many commercially available shower systems dedicated to decontaminating personnel.²⁶⁵

²⁶⁴ <http://www.nor-e.com/IDecon.htm>,

<http://www.homelandsecurityequipment.com/HomelandSecurityApproved%20EquipmentList.htm#8>,

http://www.allhandsfire.com/Merchant2/merchant.mvc?store_code=AHF&screen=PROD&product_code=SS-PPDK

²⁶⁵ http://www.ppsgb.com/pages/products/decontamination_showers.htm,

http://www.cbrneworld.com/capability_mavatech.html

Specifications for Corridor Module

A. Overview

This is a purely architectural module that will be used to connect the office, laboratory and living quarter modules safely. With the use of corridor modules, there should be no need for personnel to be on the deck of the ship unless they are in HAZMAT gear. Corridors will act not only to connect personnel, but also as conduits for infrastructural necessities, such as electrical wiring, pipes, and telecommunications.

There should be a variety of corridor modules, with easily-configured doors, in standard 20' and extended 40' lengths. Corridors should be insulated and sealed at the doorways to protect from possible airborne contaminants. For additional stability, they should be welded to the surface of the ship.

Corridors will be set up when the TEU 'village' is assembled according to a pre-planned map. Assembly work will primarily be done by longshoremen.

Specifications for Power Generator TEU

A. Overview

This TEU will consist solely of a standard electrical power generator²⁶⁶. Maintenance personnel will be onboard, but their primary station will be in an office module.

B. Personnel

1. There will be three Seabees, trained at the Prime Power School, to set up and maintain the generator(s)²⁶⁷.

C. Equipment

1. Equipment will consist solely of one or more DOD Standard mobile electric power (MEP) generators.²⁶⁸
2. At time of writing, it appears that the military does not have a generator that is specifically TEU-sized²⁶⁹. In order to retain customizability, and add protection and stability to the existing generators, it is envisioned that one or more standard large generators (such as the legacy system MEP-012A²⁷⁰) might get packaged into a TEU.

D. Environmental Considerations

1. MEPs, as a result of being designed to spec by the DOD, are equipped to handle less-than-ideal environments.²⁷¹
2. The packaging in the TEU should add an extra level of protection against possible CBRN elements in the atmosphere.

E. Agency Partnerships

1. 249th Engineer Battalion
 - a) This battalion, along with the Prime Power School offers training in maintaining electrical systems, specifically MEPs.
 - b) “The course lasts approximately 29 weeks and provides students with the necessary knowledge and skills to install, operate, and maintain medium voltage electrical power plants.”
 - c) “The year long Prime Power Production Specialist Training Course trains Active and Reserve Army soldiers and Navy Seabees. Upon

²⁶⁶ <http://www.globalsecurity.org/military/systems/ground/mep.htm>

²⁶⁷ <http://pps.belvoir.army.mil/>

²⁶⁸ <http://www.pm-mep.army.mil/>

²⁶⁹ Some generators are roughly TEU-sized, such as the MEP-PU-810A, which comes in at 21’x8’x8.5’.

<http://www.pm-mep.army.mil/technicaldata/dpgds.htm>

²⁷⁰ <http://www.pm-mep.army.mil/technicaldata/750kw.htm>

²⁷¹ <http://www.globalsecurity.org/military/systems/ground/mep.htm>

graduation, Army personnel are awarded **MOS 21P20** and Navy personnel awarded **NEC 5633**.²⁷²

2. Mobile Utilities Support Equipment (MUSE)

a) MUSE primarily works with the US Navy and US Marine Corps to supply and maintain generators.²⁷³

F. Operations Center

No interaction with the Operations Center is expected to be needed.

²⁷² <http://249en.belvoir.army.mil/pps/ppsover.htm>

²⁷³ https://portal.navfac.navy.mil/portal/page?_pageid=181,3968553,181_3968596&_dad=portal&_schema=PORTAL

Specifications for Sewage Treatment Module

A. Overview

This module will handle sewage (or black water) treatment and storage while the platform/transport vessel is at sea.

B. Personnel

1. Three Seabees will be assigned to this module to set up and maintain the units that will be used on the mission. The number of units will be adjusted to cover the changing numbers of personnel on each mission.
2. Seabees should have received training in the maintenance of black and gray water treatment systems, as well as working in a contaminated environment.

C. Equipment

1. To protect the environment around the ship, the treatment system should be closed-loop, with no effluent discharged at any point. This is semi-standard in Naval gray water and black water treatment methods, as Navy shipboard wastewater may be more concentrated with contaminants than commercial wastewater.²⁷⁴
2. The treatment system, ideally, would fit into a standard TEU, or otherwise be able to easily integrate with the other containers, size-wise. Such modular treatment options have been developed already, for use in treating on-ship hazardous wastes as well as gray- and black water.²⁷⁵

D. Environmental Considerations

1. Modules will be fastened firmly to the deck, and not moved for the duration of the mission to ensure stability.
2. Wherever possible, modules should be contained within TEUs that have been specially prepared to protect the equipment from contaminants in the environment.
3. Otherwise, standard maritime precautions should be taken to protect against damage caused by water, high winds, or high seas.

E. Agency Partnerships

1. No agency partnerships should be necessary.

F. Operations Center

1. No input from the Operations Center should be necessary.

G. Similar Projects

1. Smith & Loveless FAST Systems²⁷⁶

²⁷⁴ http://www.navysbir.com/n07_3/n073-207.htm

²⁷⁵ <http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA371422>

²⁷⁶ <http://www.marinefast.com/>

- a) The FAST (Fixed Activated Sludge Treatment) biological treatment systems are lightweight, modular treatment systems developed for a wide range of ships, from small commercial vessels to ore carriers. S&L also has capabilities to convert already-existing Navy Containment Holding Tanks to the FAST system.
- b) The FAST system is in use in Canadian maritime coastal defense vessels (MCDV), and has been tested on the HMCS *Moncton* for potential use onboard USN vessels.²⁷⁷

2. Aqua-Sans

- a) Chrysler Space Division has developed a no-discharge, nonbiological sewage disposal system that uses mineral oil as the flush fluid. Waste is separated from the mineral oil by gravity in holding tanks, allowing the fluid to be reused, and the waste to be carried to an incinerator or other disposal facility.²⁷⁸

3. Navy SBIR

- a) The Navy is currently developing a modular system specifically for handling the disposal of wastewater in Littoral Combat Ships. This system is envisioned as a supplement to existing disposal systems.²⁷⁹

²⁷⁷ <http://www.dt.navy.mil/wavelengths/archives/000068.html>

²⁷⁸ <http://ntlsearch.bts.gov/tris/record/tris/00095344.html>

²⁷⁹ http://www.navysbir.com/n07_3/n073-207.htm

Specifications for Waste Removal Module

A. Overview

As the final component in the maritime decontamination process, the Waste Removal Module provides leak proof containment for all waste material remaining after decontamination. The TEU will safely transport a wide variety of hazardous waste material from the initial site of contamination to the home seaport for further processing. The comprehensive design of this module focuses on the need for security and versatility during the end phase of response to a CBRN incident.

B. Layout and Utilities

1. The TEU will be divided into two sections, with the front half designated for liquid hazardous waste and the back half for dry hazardous waste.
2. All areas must be well-lit and well-ventilated for the safety of personnel.
3. An integrated climate control system will monitor the temperature and humidity of the TEU interior.²⁸⁰
4. A sprinkler system installed into the ceiling will provide a means of fire suppression.²⁸¹

C. Storage Capabilities

1. Fifty-five gallon closehead drums will contain all liquid waste.²⁸²
 - a) The inside of the drums must be lined with a material that does not react with any chemical or biological agents.²⁸³
 - b) The drums must safely hold and transfer a range of liquid waste.²⁸⁴
 - 1) Process wastes
 - 2) Lab chemicals
 - 3) Acids
 - 4) Solvents
 - 5) Polychlorinated biphenyls (PCBs)
 - 6) Flammables and combustibles
 - c) Drums are lightweight and can be easily rolled on and off the TEU using a hand dolly.
2. Type A containers certified to transport radioactive materials will contain all nuclear waste.²⁸⁵
3. Permanent drum cabinets installed along the inside TEU walls will house the fifty-five gallon drums and Type A containers.²⁸⁶

²⁸⁰ <http://www.uniteamcontainer.com/container/wellheadelectricalinstallationbuilding.html>

²⁸¹ <http://www.crossfiretrade.com/controll.php?/customcontainers/viewui>

²⁸² <http://www.dixiepolydrum.com/drumscontainers.html>

²⁸³ http://www.uwgb.edu/BusFin/SafetyRisk/Policy/hazardous_waste/hazardouswastedisposal.htm#10

²⁸⁴ http://www.newarkcarting.com/hazardous_wate.htm#TRANSPORTATION

²⁸⁵ <http://www.nrc.gov/reading-rm/basic-ref/teachers/11.pdf>

²⁸⁶ http://www.securallbuildings.com/hazardous_waste.asp

- a) The front section of the TEU can hold eight cabinets each containing two drums and four Type A containers.
4. The back section of the TEU will house a permanent industrial skip capable of holding twelve cubic yards of dry hazardous waste.²⁸⁷
 - a) A rolling dolly can be used to transport material to and from the dry waste skip.

D. Packing and Transport

1. Polyethylene containers will be used to transfer all liquid waste from the decontamination area to the fifty-five gallon drums.²⁸⁸
 - a) Rather than pouring the waste into the drum, the filled polyethylene containers are placed inside the drum for ultimate protection.
 - b) All open space is filled with an absorbent material such as vermiculite to contain accidental spills.
2. Multiple agents must be kept separate at all times to avoid reactions.
3. A computerized labeling/tracking system will create an inventory of the contents in each container.²⁸⁹
 - a) The following information will be entered into the system upon packing:
 - 1) Type of waste contained
 - 2) Amount and concentration of waste
 - 3) Area of the contaminated vessel waste originates from
 - 4) Special considerations (flammable, reactant, etc.)
 - b) A label with all the abovementioned information will be printed and applied to the container and drum cabinet.
 - c) Each label will include a barcode that can be scanned for tracking purposes using a handheld reader.
4. Upon arrival in port, all hazardous material will be subject to recycling, incineration, sewerage/water treatment, chemical landfill and/or other method of disposal.²⁹⁰
5. The interior of the TEU and all containers will undergo decontamination upon return to home port, allowing for rapid redeployment and reuse.

E. Environmental Considerations

1. Waste material will be protected from harsh maritime and weather conditions by the durable, watertight TEU exterior.
2. To prevent tipping, the dry waste skip/dumpster and all drum cabinets will be bolted to the TEU floor.
3. In the event of fire, the internal sprinkler system will automatically activate to suppress flames.

²⁸⁷ <http://www.skipawayltd.co.uk/skipaway-skip-hire.htm>

²⁸⁸ <http://palimpsest.stanford.edu/waac/wn/wn06/wn06-2/wn06-205.html>

²⁸⁹ <http://www.pollutioncontrol.com/services/haz/hazwaste.html>

²⁹⁰ <http://chemcare.univarusa.com/>

F. Personnel

1. Damage Controlmen Third Class (DC3) Navy rating²⁹¹
 - a) Civilian equivalent of this position is an Environmental Health and Safety Technician.
2. Responsibilities
 - a) Securely pack all waste material
 - b) Load and unload waste containers from TEU
 - c) Enter all waste information into the computerized labeling/tracking system
 - d) Inspect all containers during transport
3. Before deployment, training on proper packaging and handling of all waste material will be issued.
4. Knowledge of hazardous material properties is recommended.
5. All necessary Personal Protective Gear will be worn at all times as instructed by the Operations Center.
6. Estimate two personnel per TEU.
7. Additional personnel will be available upon arrival in port to oversee land transportation and final treatment/disposal of all waste material.

G. Operations Center

1. Experts in the onshore Operations Center will gain information on the waste material through the computerized labeling/tracking system.
2. Personnel from the Waste Removal Module will gain further instruction and guidance on handling waste material from the Operations Center.
3. The Operations Center will be responsible for preparing onshore personnel for the arrival of the waste material.

H. Agency Partnerships

1. PHMSA Office of Hazardous Materials Safety²⁹²
 - a) Transportation Regulations Specialists are knowledgeable of all DOT regulations and can advise decontamination personnel on the proper containerization and transportation of hazardous material.
2. Environmental Protection Agency²⁹³
 - a) Hazardous waste experts from the EPA can oversee the proper storage and handling of all hazardous waste in compliance with their official standards.
3. U.S. Department of Energy²⁹⁴
 - a) Officials from the Office of Civilian Radioactive Waste Management can assist in the packing and transportation of nuclear material.

I. Similar Projects

²⁹¹ http://buperscd.technology.navy.mil/bup_updt/508/OccStandards/CHAPTER%2021.htm

²⁹² <http://hazmat.dot.gov/>

²⁹³ <http://www.epa.gov/epaoswer/osw/tsds.htm>

²⁹⁴ <http://www.ocrwm.doe.gov/transport/index.shtml>

1. Environmental Compliance Products²⁹⁵
 - a) ECP has designed and built multiple versions of a standalone modular storage building to house hazardous waste.
 - b) The facilities produced by ECP provide examples of the best storage configurations.
2. Uniteam International AS²⁹⁶
 - a) Norway's Uniteam constructs small-scale containers for hazardous waste.
 - b) The specially designed flooring, ventilation system, and other features of these containers serve as ideal models for the operational aspect of the Waste Removal Module.

²⁹⁵ <http://www.hazardous-material-storage-buildings.com/models.htm>

²⁹⁶ <http://www.uniteam.org/shelter/hazardousprotection.html>

Specifications for Water Purification Module

A. Overview

This module will consist of a dedicated water purification system, able to turn seawater that may have been contaminated into potable water. The water filtration system, storage, and delivery method will all be contained in a standard TEU, allowing multiple configurations as well as customizability for the specific number of personnel that will need potable water. The TEU's design will address the unique issues inherent in being self-contained, and in a hazardous situation, whether that is as a result of a CBRN incident or the issues inherent in being on a ship.

B. Personnel

1. Three Seabees will be assigned to this module to set up and maintain the water purification units that will be used on the mission. Number of units will be adjusted to cover the changing numbers of personnel on each mission.
2. Seabees should have received training in the maintenance of water purification systems, as well as working in a contaminated environment.

C. Equipment

Contained within this TEU will be:

1. Seawater intake
2. Purification system
 - a) Reverse osmosis has been shown to be able to process seawater, as well as water contaminated with NBC agents, and make it potable²⁹⁷
3. Power source -- ideally this will be a generator contained within the TEU and separate from the power source for the rest of the TEUs.
4. Storage
 - a) TEU will be able to safely store water as needed in inert containers contained within the TEU so as to prevent possible CBRN contact.²⁹⁸
5. This TEU will be completely self-contained and require minimum power, operation and maintenance costs, and have a rapid production rate, supplying water for drinking, cooking and cleaning to personnel and laboratory modules.
 - a) Modular water purification systems already exist that require only a 60 KW generator to produce 250,000 gallons of water in 3 days, within a TEU-sized module.²⁹⁹

D. Environmental Considerations

1. The module will remain independent of both the ship's systems and the power system for the other TEUs, ensuring a dedicated power system.

²⁹⁷ http://enr.construction.com/sp_Projects/green/archives/050815b.asp

²⁹⁸ http://www.lexdon.com/article/SFAs_Defense_Product_Division_Receives/553.html

²⁹⁹ http://enr.construction.com/sp_Projects/green/archives/050815b.asp

2. Using existing Naval technology, this TEU should be able to operate despite environmental issues in a marine setting.³⁰⁰

E. Agency Partnerships

1. Naval Facilities Engineering Command (NAVFAC)³⁰¹
 - a) NAVFAC offers testing, consulting, and evaluating services concerning water purification systems. They are particularly interested in reverse-osmosis methods, and have historically worked with the Navy before, particularly in training Seabees with TACOM (U.S. Army Tank-Automotive and Armaments Command).
2. EPA³⁰²
 - a) The EPA is tasked with tracking and evaluating the safety of the environment, with a particular emphasis on safe water resources. Their research and testing facilities can help the Navy create a faster, more efficient and safer water purification system.

F. Operations Center

1. This module should not need to interact with the Operations Center.

G. Similar Projects

1. Expeditionary Unit Water Purifier (EUWP)³⁰³
 - a) EUWP, designed by Village Marine Tec, is a large-scale water purifier, capable of handling 100,000 gallons of water per day. It is able to purify water from almost any source, including water with NBC contaminants. The EUWP is the size of two standard TEUs, and thus would be configurable with the TEU system. EUWP uses reverse osmosis to purify seawater, and has been used in both military and civilian situations where potable water is unavailable through usual means.³⁰⁴
2. Alion
 - a) Alion Science and Technology was recently awarded a contract with Naval Surface Warfare Center, Carderock Division – Philadelphia to design and fabricate a high-capacity, high-purity water purification unit.³⁰⁵ Alion has a history of working closely with the Defense Department to develop technologies to aid in homeland defense.³⁰⁶
3. SFA-DPD³⁰⁷
 - a) Tactical Water Purification Systems
 - 1) “The TWPS incorporates advanced micro-filtration technology to filter out silt and biological materials including disease-causing

³⁰⁰ https://portal.navy.mil/portal/page?_pageid=181,3997941&_dad=portal&_schema=PORTAL

³⁰¹ https://portal.navy.mil/portal/page?_pageid=181,3997941&_dad=portal&_schema=PORTAL

³⁰² <http://www.epa.gov/epahome/aboutepa.htm>

³⁰³ <http://www.villagemarine.com/euwp.html>

³⁰⁴ <http://www.usbr.gov/pmts/water/research/EUWPkatrina.html>

³⁰⁵ <http://www.encyclopedia.com/doc/1G1-143715214.html>

³⁰⁶ <http://www.alionscience.com/index.cfm>

³⁰⁷ <http://www.sfa.com/DPD/dpd-products-twps.htm>

microorganisms such as Cryptosporidium. It also includes advanced, high salt rejection, reverse osmosis technology to produce drinking water from the extremely salty seawater sources in the Middle East.”

Specifications for Storage Module - Uncontaminated

A. Overview

This module will store objects during transport and throughout the decontamination ops. Unlike its sister module, this module is specifically dedicated to objects and materials that are uncontaminated and should not come into any contact with contaminated personnel or things.

The module, which will not need to be staffed, will be arranged with a series of shelves, each of which will contain securable bins that can easily be labeled. No water hookups are necessary, although the TEU will be converted slightly to better seal against the environment, and include lighting and environmental controls.

Specifications for Storage Module - Contaminated

A. Overview

This module is dedicated to storing objects during transport and decontamination, and is a sister module to Storage Module – Uncontaminated. This module will specifically store materials that are or may have become contaminated, as well as safely storing samples collected from the contaminated ship if necessary.

Although structurally this TEU will be similar to the other storage modules, with environmental, lighting and external adjustments, it will also contain sealable bins in which contaminated objects can safely be stored, and personnel may be able to enter and leave without coming into contact with previously-stored objects. Additionally, due to the sensitive nature of the contents, more rigorous security to access this module will be required.

Appendix 3: Economic Development Document

US Navy CBRN Emergency Response: An Opportunity for economic and industry development

Introduction: Currently the United States Navy (USN) is the only military service without a dedicated ability to respond to a Chemical Biological Radiological or Nuclear (CBRN) event. Working on contract with the Department of Defense – Office of Naval Research we are working to propose a way to create an emergency response CBRN capability via a phased response system, specialized R&D, and small scale highly specialized manufacturing. The specialized R&D and manufacturing components of this project require a confluence of location and knowledge clusters which the Philadelphia area, and particularly the Navy Yard provides.

This document will lay out the context for our work with the Navy and the proposed phased emergency response system. Additionally the document briefly describes the functions and scope of the needed support activities including the pivotal role of the Philadelphia Center for research and manufacturing. Finally, the paper suggests several other business opportunities that exist for the research and manufacturing cluster proposed.

Context and Scope: The increased operational tempo and changing mission profile driven by the Global War on Terror (GWOT) leaves the Navy, traditionally protected from CBRN risks by operating in deep blue ocean, likely to see a rise in CBRN accidents and attacks. The Navy's changing mission profile, as it operates more and more in brown (rivers) and green (close to shore) waters, leaves the fleet more exposed to terrorists and asymmetrical attack. Currently if a Navy vessel were affected by a CBRN attack or accident the Navy would need to bring the affected vessel into port or sink it at sea.

Need: The ability to conduct consequence management/mitigation and rescue and restore operations as needed on both USN vessels and other vessels of national interest at sea. This will avoid the need to bring contaminated cargo/vessel into a port facility and, if possible, restore Navy Vessels to active service as quickly as safe/possible.

Proposal: CBRN events have broadly similar patterns of divisible phases. In most cases the incident is sudden: caused by a fire, an explosion, a rapid change in pressure, an attack, a rupture. This acute phase must be successfully managed to limit the loss of life and human injury, to keep the ship afloat and as functional as possible, and to contain the incident initially. The second phase brings outside resources to the incident to begin containment, protection, and treatment. These resources (equipment and personnel) are logistically or cost prohibitive to have on each vessel as organic capability. The third phase involves more substantial, longer term efforts utilizing specialized equipment and personnel who must be able to conduct intensive clean up procedures while limiting risk and exposure to other ships and people, minimizing disruption, and culminating in the return of the ship(s) to active duty.

1. Phased emergency response concept

Timeline		Response	Activities
Prior to CBRN event		Pre-event preparations	<ul style="list-style-type: none"> • Entry level PPE and survival skills training for all Navy personnel • Entry level CBR-D training that includes basic chemical, biological, and radiological defense (CBR-D) training as outlined in the USN Basic Military Requirements for all Navy personnel • DC "A" School for all Navy Damage Controlmen, including the CBR-D element, followed by further on-the-job training • Periodic CBRN Unit Defense training for all Navy personnel • Pre-deployment CBRN Unit training exercises for all deployable units • Ship-wide DC readiness training onboard Navy vessels with a segment set aside for CBRN training • Training for Navy DC personnel at Army's Chemical School as outlined for Army CBRN specialists, with courses altered to be geared specifically toward Navy CBRN training • Apply Air Force's system of requiring additional training for personnel going to high-, medium-, and low-level threat deployment areas • CBRN defense needs should be taken into consideration during vessel design and purchasing procedures • Training and Exercise Program Executed leveraging NORTHCOM Joint Exercise Program, to include table-top and/or command post exercises, ship breakout simulation exercise aboard JHSV
Within 12 hours of CBRN event		Phase I: Local Response	
<1 hour after CBRN event			<ul style="list-style-type: none"> • Contamination event identified by DC personnel • General & chemical alarms sounded by officer of the deck
<3 hours			<ul style="list-style-type: none"> • Designated onboard CBRN team (DC personnel) to evaluate extent & severity of incident • Commanding Officer notified of event
3-5 hours			<ul style="list-style-type: none"> • Ship's medical officers prepare for primary care for unit casualties • Mission oriented protection posture (MOPP) determined and implemented
4-7 hours			<ul style="list-style-type: none"> • Defense plan implemented • Proposed decontamination sites designated • CBRN detectors activated

<12 hours		<ul style="list-style-type: none"> • The ship's Collective Protection System (CPS) used to seal off areas necessary to operation of ship that are uncontaminated • Use of PPE to re-enter contaminated part of ship • Countermeasures washdown (CMWD) system used where possible • Triage and evacuation as needed • After preliminary stabilization complete, crew to respond in established manner for type of CBRN decontamination, if known (N,B,or C outlined in report) • Reports of ship's condition and any decontamination actions already taken are prepared in preparation for Phase II arrival
12-48 hours after CBRN event	Phase II: Emergency & Expert Response	
12-48 hours after event	Spiral Alpha: Airborne Element	<ul style="list-style-type: none"> • Arrival of airborne element formal evaluation team at site of incident • Situation gauged by evaluation team, including shipbuilding engineers & scientific advisory group • Testing for CBRN contaminants
<1 hour after arrival		<ul style="list-style-type: none"> • First external response unit onboard providing CBRN expertise in detection, decontamination and protection
2-3 hours after arrival		<ul style="list-style-type: none"> • Secure the vessel
4-6 hours after arrival		<ul style="list-style-type: none"> • Decontaminate personnel • Establish an Operations Chain of Command • Preliminary decontamination operations
48 hours to 2 weeks after CBRN event	Spiral Bravo: Fast Response Element	<ul style="list-style-type: none"> • Arrival of Fast Response Vessel containing C4I/IO (command, control, communications, computers, and intelligence/information office) • New Commanding Officer tasked with overseeing decontamination will take over
Upon arrival		
1-2 hours after arrival		<ul style="list-style-type: none"> • Fast Response Vessel to tie off to contaminated vessel
2-4 hours after arrival		<ul style="list-style-type: none"> • Full scale personnel decontamination and ability to provide interim life support pending medevac
		<ul style="list-style-type: none"> • Secure the vessel • Decontaminate personnel • Establish an Operations Chain of Command • Preliminary decontamination operations
Up to 3 weeks after arrival		<ul style="list-style-type: none"> • Containment of CBRN material and recovery and restoration conducted by USMC CBIRF including Recon, Decon, Medical, Security, Service Support • Commanding Officer evaluates the need for Phase III operations; if deemed necessary, the ship will be prepared for full-scale decontamination • Situation reports prepared for Phase III personnel
Areas shaded in gray take place simultaneously across Phase IIA and		

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<i>Phase IIB</i>		
No later than 3 weeks after CBRN event	Phase III: Thorough Decontamination Response	
Arrival no later than 3 weeks after event		<ul style="list-style-type: none"> • Modular self-sustaining decontamination vessel arrives with relevant TEU modules onboard for decontamination based on situation reports from Phase II
Upon arrival 1-2 hours after arrival		<ul style="list-style-type: none"> • All Phase II operations move to the Phase III vessel with all personnel reporting to the scene Commander • Decontamination vessel uses sensors and robotics to conduct a scan of the affected area(s) • Dedicated clean area onboard vessel is allocated to handle personnel and equipment as the platform/transport vessel operations are conducted
3-5 hours after arrival	Option IIIA: In-Transit Variant Wet	<ul style="list-style-type: none"> • Commanding Officer selects the most appropriate of five possible delivery options, based on the size and condition of the ship, and the necessity of returning it to immediate active duty • Necessary decontamination equipment is airlifted to the site • Decontamination vehicle will be sustained by pre-po vessel and security comport with USN TTP • Watertight envelope is maintained and vessel is capable of powering itself • Basic containment to mid-level decontamination occurs in-transit, with the result that the ship is clean enough to be accepted at port for entry
	Option IIIB: In-Transit Variant Dry	<ul style="list-style-type: none"> • Necessary decontamination equipment is airlifted to the site • Decontamination vehicle will be sustained by pre-po vessel and security comport with USN TTP • Vessel is deemed incapable of powering itself and is transported using heavy lift ship • Mid-level to complex decontamination occurs in-transit, with the result that the ship is clean enough to be accepted at port for entry
	Option IIIC: At Sea Full-Scale Decon Variant	<ul style="list-style-type: none"> • Equipment is sealifted using a decon vessel contingent capable of organic sustainment for up to 21 days • High-level decontamination takes place at-sea, with the result that the pre-po vessel is at minimal safety risk and fully capable of sustaining direct action
	Option IIID: At Sea Large-Scale Decon Variant	<ul style="list-style-type: none"> • Equipment is sealifted using a decon vessel contingent capable of organic sustainment for up to 21 days • If possible, large-scale complex decontamination may take place at sea with the result that the vessel is capable of supporting direct action • If the size of the vessel or level of damage is prohibitive, the ship is returned to port for refit

Option IIIE: Rapid
Release Variant

- Occurs during war-time emergencies
- Equipment is delivered via sealift with additional assets transported as needed
- Decontamination vehicle externally supplied by pre-po vessel and other availables
- Large-scale decontamination occurs at-sea, leaving the vessel as clean as possible within current tactical/strategic constraints
- Vessel is returned to fleet at reduced capabilities for limited action

2. Operations center

Waterborne CBRN incident 911 call center, a 24/7, 365, uniformed officer staffed, with/reachback to other relevant organizations such as EPA, CDC, etc. and also close working relationship with the engineering/R&D facility (the Philadelphia center for now)

3. Engineering, production maintenance research facility

Working in tandem with the Operations Center will be a manufacturing and research center located at the PNSY. While the Operations Center will monitor external affairs and function as a reachback center, the Manufacturing and Research Center will specialize in the physical components of the decontamination method, ultimately designing and then creating and stocking state-of-the-art laboratories, communications facilities, living spaces and other TEU-based elements to be used during operations.

In the early phase of production, this Center will take the conceptual work already completed and design and prototype the TEUs and any new technology that will be used in them. As the project transitions to a program, the Philadelphia center will be responsible for high-end, low volume manufacturing of TEUs. While the primary focus of production will be TEUs for decontamination operations, a variety of laboratories, offices and living spaces will be created, and some could have roles and purposes beyond the scope of this project.

The Philadelphia Center, over time, becomes the maintenance and repair hub for TEUs, most of which are sent to prepositioned locations around the globe. In tandem with designing and producing TEUs, the Center will feature a research branch dedicated to technological and pharmacological research, building on industries already heavily present in the Philadelphia area and allowing them expansion. Bringing new industry to the area, this research branch will also concentrate on innovations in decontamination methods, materials and technology. In its final state, the Philadelphia Center will be a manufacturing and research hub, able to serve both DOD and civilian needs, while supplying fully-stocked TEUs to nodes around the globe.

Working with Building 100 Innovation Center and PIDC, the Navy can create a series of custom research projects based on feedback from the field and known gaps in current capabilities. Due to the variety of situations these TEUs will be placed in, broad experience and research will be possible, as well as more targeted projects allowing a unique mixture of development and manufacturing.

The eventual goal is a small (100-200) person multiform/multi-sector cluster of companies that will work in tandem on CBRN consequence management research and development. The outcome will be a growing industry in a high tech/high skill environment. This method of remediation, with particular focus on at-sea environments, could develop into a method by which the Navy moves more expeditiously through deactivated fleet recycling.

Staffing for the Philadelphia Manufacturing and Research Center is envisioned to run along lines of 12-15 total uniformed Navy personnel, working in tandem with similar numbers of civilian DOD employees. The rest of the employees will be contractors and related firms that cluster in the area, attracted by the contracts, contacts, incentives and the informal knowledge networks that will spring up around this state-of-the-art center.

Local Benefits: The project would create 100-200 high tech, high skill jobs and create a cluster of companies and projects focused on consequence management, high end property recovery/salvage, and environmental remediation. In addition to the emergency decontamination issue, which is the purview of this project, the aspect of the phased response system could easily be used for other environmental remediation efforts including Superfund sites, decommissioned Navy vessels and Brownfield locations, among others.

Appendix 4: Current PNSY Activities

THE NAVY YARD BUSINESSES	# of Employees	Description	NACIS Code
Aker Philadelphia Shipyard, Inc.	1300 most work in Philly	constructs world-class quality ships and owns vessels for bare boat charter	
AMSEC	29	a full service supplier to the Navy and commercial maritime industry, providing naval architecture and marine engineering, naval ship systems assessments, maintenance engineering, acquisition program development, shipyard industrial engineering, and complete logistics services from technical manual development to provisioning documents, to spare parts management and training	541712-R&D in the Physical, Engineering, and Life Science
Anthropologie	105	clothing, jewelry, and objects for home	448120-Women's Clothing
AppTec Laboratory Services	45	Laboratory testing services for the following industries: Biotech/Biopharm Industries; Chemical Germicide Industry [Product efficacy testing for disinfectants and other products]; Medical Device Industry Biocompatibility [genotoxicology; sterilization, reuse and viral/process validations; quality assurance support, full-service microbiology, and package testing to help manufacturers meet regulatory requirements]	621511-Medical Laboratories
Barthco International, Inc.	250	provides global logistics and freight forwarding services; arranges air and ocean transportation of its customers' cargo through a network of independent carriers; specializes in working with biotech companies and in handling shipments of fine art, valuables, and live animals; provides customs brokerage and warehousing and distribution services; manages over 700,000 shipments a year	488510-Freight Transportation Arrangement
Collegiate Consortium for Workforce and Economic Development	5	a non-profit organization that is a partnership of Drexel University and five area community colleges / provides a comprehensive, coordinated approach to developing a highly skilled workforce for the region	
Canadian Pacific Railway		rail freight service	482111 (Scranton Branch)
Changing World Technologies	25	identifies emerging technologies that specifically address the needs and problems in the energy and environmental arenas; revolutionizing renewable energy by changing the way in which organic waste materials are utilized, thereby providing a platform for sustainable development	32519 (Hempstead, NY)- Other Basic Organic Chemical Manufacturing

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Chapel of the Four Chaplains		A chapel that was dedicated on February 3, 1951 by President Harry S. Truman to honor four Army chaplains (soldiers) of different faiths who were killed in action when the USAT Dorchester was hit by a torpedo and sank on February 3, 1943. They helped other soldiers board lifeboats and gave up their life jackets when the supply ran out.	
Connolly Consulting		recovery auditor and consultant.	
Cushman and Wakefield of PA, Inc.	75	Real Estate Agent/Manager	
Del-San Environmental, Inc.	2	trade contractor	562910- Remediation Services
DiNic's of Snyder Ave., Inc.		bar, tavern	
Duke Energy Generation		leading developer, owner and operator of power generation solutions; utilizing natural gas and various solid fuels, and currently manages over 5,000 megawatts of power generation / Their focus is to improve your profitability by reducing your energy costs, while increasing reliability and reducing environmental impact.	
EDO Corporation		designs and manufactures a diverse range of products for defense, intelligence, and commercial markets, and provides related engineering and professional services / EDO's advanced systems are at the core of the transformation to lighter, faster, and smarter defense capabilities.	334511 (New York, NY)
EG&G	13,000 (in 2005)	provides program management, systems engineering and technical assistance, and operations and maintenance services to a variety of federal agencies, primarily the Departments of Defense and Homeland Security	561210 (Gaithersburg, MD)- Facilities Support Services
Excel Welding	10	offer a full line of welding, cutting, tools, safety, and industrial supplies to support building, manufacturing, and fabrication	
Free People	75	Clothing	
Freedom Sciences, LLC	3	Medical, Dental, and Hospital Equipment and Supplies	423450-Medical, Dental, Hospital...Wholesalers
Frog Commissary Catering	150	catering	
Geo-Centers, Inc.	1	engineering services	541330-Engineering Services
General Dynamics Corporation		Ship Building and Repairing	
George Young Company	49	installations of Baggage Handling Equipment, handling large works of fine art, hygienic equipment installations for the pharmaceutical industry, high hoisting and installation of power generation and distribution equipment.	238290-Other Building Equipment Contractors
Gibbs & Cox, Inc.	4	naval architecture and marine engineering firm	541330-Engineering Services

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Hargrove, Inc.	185	custom exhibit, special event, and trade show contractor	
Healthmark Incorporated		offers comprehensive worker's compensation medical services to help employees who have had an accident, injury, or illness make a smooth transition to the workplace	
International Cruise Terminal		cruise ships	
Iofy Corporation		sells audiobooks / multimedia company	no search results
Iroko Pharmaceuticals LLC	15	acquires, develops, and maximizes the potential of currently marketed pharmaceutical products	325412-Pharma. Preparation Manufacturing
Jamie Record Company			no search results
Landmar Enterprises, Inc.	12	New Construction & Renovations Of Commercial Buildings	236220-Commercial and Institutional Building Construction
Life Cycle Engineering	21	engineering services, industrial machinery	541330-Engineering Services
Living Naturally, LLC	40	leading provider of innovative technology and marketing services to the natural health industry	
Lockheed Martin		Research & Development Of Space Launch Vehicles	
McAllister Towing of Philadelphia, Inc.	350	marine towing and transportation companies	
McKean Defense Group	25	engineering and Information Technology (IT) consulting company	
MetroKids Publications		creates monthly publications that help Delaware Valley families take advantage of the vast resources — both educational and recreational — available in our culturally rich and diverse community	
Menasha Packaging Company, LLC	150	Manufactures Corrugated/Solid Fiber Boxes	322211-Corrugated & Solid Fiber Box Manufacturing
MinusNine Technologies	5	Nano adhesives, coatings & polymers	MFG Adhesives/Sealants (no NAICS code available)
Moran Towing Corp		operates the largest and most versatile fleet of harbor tugs servicing the major port cities and facilities located on the Delaware River	
Mothers Work, Inc.	380	Retails Maternity Clothing	
Nason Construction, Inc.	5	Nonresidential Construction Industrial Building Construction	236220-Commercial and Institutional Building Construction
NAVMAR Applied Sciences Corp.	100 - 250	professional engineering, assists in strategic and responsive problem solving for the DOD and other organizations	
Northrop Grumman Systems Corp.		global defense and technology company	
P&A Associates	3	Real Estate developers	522298-All Other Nondepository Credit Intermediation
Penn State Great Valley	43 full-time, 66 part-time faculty	Data Processing School	

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Pennsylvania Horticultural Society		provides great events, activities, and publications for novice gardeners & experienced horticulturists	
Philadelphia Industrial Development Corp.	55	promotes economic development throughout the city	
Philadelphia Shipyard Development Corp.		working together with ShipyardXchange to establish integrated websites, with access to all of the 14 Kvaerner shipyards throughout the world, to provide exchange and collaborative capabilities for all the suppliers in their network	
Port of Philadelphia & Camden		cruise terminal	
Potomac Navy Yard, LLC			no locations found in Philadelphia
Printcrafters, Inc.	30	commercial printing	
Q.E.D. Systems, Inc.	over 400	Information Technology (IT), Engineering, Industrial Services and Logistics	no locations found in Philadelphia
Quaker Electrical & Mechanical Contractors, Inc.		electrical and mechanical engineering	no locations found in Philadelphia
Rebellion Pictures, LLC		film production company	
Resource America, Inc.	224	a specialized asset management company that uses industry specific expertise to generate and administer investment opportunities for its own account and for outside investors in the real estate, equipment finance, structured finance and private equity sectors	522292-Real Estate Credit
Rhoads Industries	1	sheet metal industrial services company	238990-All Other Specialty Trade Contractors
River Associates	15	Water Transportation of Freight & Tugboat Services	483211-Inland Water Freight Transportation
Rotem Company	215	Rail Car Builder	(Rotem USA Corp) 336510-Railroad Rolling Stock Manufacturing
Sautter's Café		restaurant	
Securitas Security Services USA, Inc.	12	largest provider of security officer services in the United States	561613-Armored Car Services; also 561612-Security Guards & Patrol Services
Steven L. Gershman, Esquire		law firm	no search results
Stonehenge Advisors, Inc.	80	Real Estate Management firm	no search results
Team Clean	250	Building Cleaning and Maintenance Services	561720-Janitorial Services
Torcon Incorporated	275	construction management services	236220-Commercial and Institutional Building Construction
Thackray Crane Rental, Inc.	50	Heavy Construction Equipment Rental and Leasing	
Unique Industries		manufacturing and distributing party merchandise	no locations found in Philadelphia
Urban Outfitters, Inc.	105	clothing, jewelry, and objects for home	
U.S. Dept. of Agriculture		responsible for the safety of meat, poultry, and egg products	

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U.S. Navy		National Security	
Vericom Technologies	1	Mobile Resource Management; manages vehicle fleets, mobile workforce and remote assets	561499-All Other Business Support Services
VITETTA		architectural and engineering corporation	
WHYY, Inc.	160	Radio Broadcast Station Television Station	
Wilmington Steel Processing Co.	25	Provides steel processing, weldments, shearing & flame cutting services	331111-Iron and Steel Mills

Appendix 5: Profiles of Relevant Companies

Key

	TEU-like containers
	May be of interest
	Likely of interest
	Located in PNSY

Company Name	Company Description	NAICS	Industry	Location
Andrew B Duffy Inc	We have more than 30 years experience in the design, testing, fabrication and repair of various regulated containers	33243	Metal Can, Box, and Other Metal Container (Light Gauge) Manufacturing	Thorofare, NJ
AK Packaging, Inc	bulk boxes, warehouse storage- website under construction			Bristol, PA
Aker Philadelphia Shipyard, Inc.	constructs world-class quality ships and owns vessels for bare boat charter			Navy Yard
AMSEC	a full service supplier to the Navy and commercial maritime industry, providing naval architecture and marine engineering, naval ship systems assessments, maintenance engineering, acquisition program development, shipyard industrial engineering, and complete logistics services from technical manual development to provisioning documents, to spare parts management and training	541712	R&D in the Physical, Engineering, and Life Science	Navy Yard
BE&K Engineering	Engineering projects for government, Dupont, other industrial and manufacturing companies; large variety of projects	541330	Engineering Services	Newark, DE
B E Wallace Products Corp	work with military, hundreds of crane models available for situations- portable, adjustable height, various weight capacities	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Malvern, PA
Capitol Environmental Services, Inc	waste reuse, treatment and disposal; environmentally friendly, variety of services	562211	Hazardous Waste Treatment and Disposal	Wilmington, DE
Cargo Plus Inc	shipping containers	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Pennsauken, NJ

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Company Name	Company Description	NAICS	Industry	Location
Changing World Technologies	identifies emerging technologies that specifically address the needs and problems in the energy and environmental arenas; revolutionizing renewable energy by changing the way in which organic waste materials are utilized, thereby providing a platform for sustainable development	32519	Other Basic Organic Chemical Manufacturing	Navy Yard
Clean Harbors Environmental Services, Inc	managing hazardous, non-hazardous, wet and dry materials. Specialized services include chemical cleaning, hydroblasting, liquid/dry vacuuming, sodium bicarbonate blasting, steam cleaning, and railcar cleaning and inspection. Locations	562211	Hazardous Waste Treatment and Disposal	Philadelphia, PA
Compact Membrane Systems, Inc	air ventilation and quality improvement, oxygen and nitrogen enriched air, vapor processors			Wilmington, DE
Container Research Corporation	services from concept and prototyping through production and testing, on-site manufacturing operation, adheres to strict, government- and industry-accepted quality control procedures throughout our operations	33243	Metal Can, Box, and Other Metal Container (Light Gauge) Manufacturing	Glen Riddle, PA
Crowley Liner Services, Inc	engineering, loading, and transportation/delivery services; Titan Salvage is a marine salvage and ship wreck removal company under Crowley; teams of marine engineers and naval architects	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Pennsauken, NJ
Current Environmental Solutions LLC	brownfields remediations, thermal treatment	562211	Hazardous Waste Treatment and Disposal	Langhorne, PA
Delaware River Stevedores Inc	utilizes specialized gear, mechanical equipment and the latest technology to provide efficient and damage free cargo services and the latest technology to provide efficient and damage free cargo services	488320	Marine Cargo Handling	Camden, NJ Philadelphia, PA
Delphinus Engineering Inc	design manufacturing, navy experience, program and project experience	33661	Ship and Boat Building	Eddystone, PA

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Company Name	Company Description	NAICS	Industry	Location
Disposal Corp of America	waste removal, open and closed containers; mostly commercial	5622	Waste Treatment and Removal	Philadelphia, PA
Duffield Associates	marine and coastal engineering, sustainable and environmental development and design	541330	Engineering Services	Wilmington, DE, Philadelphia, PA Cape May, NJ
D&S Warehousing, Inc	packaging, warehouse storage, and trucking	4931	Warehousing & Storage	Newark, DE
Eagle Instruments	biochem kits with protective gear, training Site under construction			Aston, PA
EDO Corporation	designs and manufactures a diverse range of products for defense, intelligence, and commercial markets, and provides related engineering and professional services / EDO's advanced systems are at the core of the transformation to lighter, faster, and smarter defense capabilities.	334511		Navy Yard
EG&G	provides program management, systems engineering and technical assistance, and operations and maintenance services to a variety of federal agencies, primarily the Departments of Defense and Homeland Security	561210	Facilities Support Services	Navy Yard
Excel Welding	offer a full line of welding, cutting, tools, safety, and industrial supplies to support building, manufacturing, and fabrication			Navy Yard
FastShip, Inc	With the addition of very simple, low-cost military features that can be installed in 48 hours, the commercial FastShip can quickly be converted to a roll-on roll-off ship that can carry wheeled and tracked vehicles, containers and personnel	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Philadelphia, PA
Fluor Enterprises Inc	services with oil and gas, petrochemical, life science, manufacturing, government services,	562211	Hazardous Waste Treatment and Disposal	Media, PA
General Air Products Inc	air coolers and compressors, custom products available	333912	Air and Gas Compressor Manufacturing	Exton, PA
Gibbs & Cox, Inc.	naval architecture and marine engineering firm	541330	Engineering Services	Navy Yard
Gloucester Marine Terminal Inc	terminal for containers, steel products, food, heavy lift, project	488320	Marine Cargo Handling	Gloucester City, NJ

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Company Name	Company Description	NAICS	Industry	Location
Howden Compressors Company LLC	products for contaminated air and gas; gas cleaning; blowers, compressors, industrial fans	333912	Air and Gas Compressor Manufacturing	Plymouth Meeting, PA
Hypex Inc.	Custom equipment, generally packaging for pharma and related industries	3327	Machine Shops; Turned Product and Screw; Nut and Bolt Manufacturing	Southampton, PA
ILC Dover, Inc	protective gear including a new CBRN hood and gas masks			Frederica, DE
Ingersoll- Rand Company	air compressors and treatment; also see lifting and material handling	333912	Air and Gas Compressor Manufacturing	Mount Laurel, NJ
Ingersoll- Rand Company	hoists, clamps, handling devices (vacuums, clamps, jhooks); custom devices	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Mount Laurel, NJ
Interocean American Shipping Corp	vessel operations, crew management, voyage repairs, shipyard overhauls, insurance and claims handling, quality in service and safety and pollution management	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Voorhees, NJ
K Line America	bulk carriers and shipping containers	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Vincentown, NJ
Keystone Boiler, Inc	sheet and plate metal, bins, tanks, etc. in aluminum, steel, tin, and brass	3311	Iron and Steel Mills & Ferroalloy manufacturing	Philadelphia, PA
Marathon Engineering and Environmental Services	brownfields remediations, site development, environmental risk assessment,			Swedesboro, NJ
Matcon USA Inc	Matcon specialize in providing solutions for handling and processing powders, granules, tablets and other materials in Intermediate Bulk Containers; international	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Sewell, NJ
Mc Dal Corporation	hoists, cranes, monorails; new and used equipment, service	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	King of Prussia, PA
McAllister Towing of Philadelphia, Inc.	marine towing and transportation companies			Navy Yard
Met Pro Corporation	air and liquid purification, pollution control	3332	Industrial Machinery Manufacturing	Harleysville, PA
Miller-Remick Corp	design and structural engineering	541330	Engineering Services	Cherry Hill, NJ
Moran Towing Corp	operates the largest and most versatile fleet of harbor tugs servicing the major port cities and facilities located on the Delaware River			Navy Yard

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Company Name	Company Description	NAICS	Industry	Location
Navmar Applied Sciences Corp.	professional engineering, assists in strategic and responsive problem solving for the DoD and other organizations			Navy Yard
P D C Machines, Inc	mostly custom products	333912	Air and Gas Compressor Manufacturing	Warminster, PA
Packer Avenue Marine Terminal	cranes, toploaders, containers	488320	Marine Cargo Handling	Philadelphia, PA
Penn Terminals, Inc	cargo, containers, loading docks	488320	Marine Cargo Handling	Eddystone, PA
Philadelphia Industrial Development Corp.	promotes economic development throughout the city			Navy Yard
Philadelphia Shipyard Development Corp.	working together with ShipyardXchange to establish integrated websites, with access to all of the 14 Kvaerner shipyards throughout the world, to provide exchange and collaborative capabilities for all the suppliers in their network			Navy Yard
PPG Industries	Coatings for packaging, marine, agricultural, industrial and chemical industries, other specialty products			Dover, DE
Pressure Products Industries Inc	large scale, purity compressors	333912	Air and Gas Compressor Manufacturing	Warminster, PA
Rhoads Industries	sheet metal industrial services company	238990	All other Specialty Trade Contractors	Navy Yard
Rock-It Cargo Holdings, LLC	loading and shipping cargo	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Huntingdon Valley, PA
Rowan Technologies, Inc	coatings for hazardous materials; in NJ	333912	Air and Gas Compressor Manufacturing	Rancocas, NJ
Sea Box Inc.	has produced military containers, can customize or modify, for sale, lease, or rent; containers for Command and Control centers, personnel, emergency medical equipment, water purification	33243	Metal Can, Box, and Other Metal Container (Light Gauge) Manufacturing	Riverton, NJ
Sky-Trax, Inc	efficient and safe warehouse storage systems	4931	Warehousing & Storage	New Castle, DE
Sph Crane & Hoist Inc	hoists, cranes, monorails; lifting equipment and accessories	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Philadelphia, PA

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Company Name	Company Description	NAICS	Industry	Location
Vacuum Processes, Inc	vacuum pumps, gauges and controllers; thermal process equipment; temp and humidity space simulation chambers; R&D, manufacturing, service, installation; helium leak detection; vacuum chambers	333912	Air and Gas Compressor Manufacturing	Levittown, PA
Wilmington Steel Processing Co.	Provides steel processing, weldments, shearing & flame cutting services	331111	Iron and Steel Mills	Navy Yard
Wilmington Tug	tug services			New Castle, DE
W.L. Gore & Associates	products for ventilation (packaging vents and dryfreeze) and filtration, sealants (gaskets, packing fibers, pumps), geochemical services (identification of environmental contaminants), and medical/healthcare (surgical, imaging, tools)			Newark, DE
Maritime Exchange for DE Valley and Bay	membership network for companies working in or related to DE River, offers hazmat training			Philadelphia, PA
Virtual Sciences	use blueprints (sketches, photos) to create animated graphics of locations			Parsippany, NJ
Technology Security Associates, Inc	DoD consulting, information assurance through testing and research, policy project support and expertise			Lexington Park, MD

Appendix 6: Environmental Remediation Business Cluster Case Study

During the budgetary hearings of August and September 2008, \$1,000,000 is earmarked for the Office of Naval Research to design and produce prototypes of the TEUs that will be part of the Emergency Response System to CBRN incidents.

After reviewing the final report *Feasibility and Top Level Design of a Scalable Emergency Response System for Oceangoing Assets*, the ONR decides to follow the report's recommendation to base the Emergency Response Research and Design Center (ERRDC) in Philadelphia. After evaluating a short list of sites, ONR determines that Philadelphia is the cost effective option that optimizes project requirement fulfillment. The Philadelphia region also offers the potential for successful business cluster growth and development. This case study illustrates how an environmental remediation business cluster develops from the ONR project activity at the PNSY.

Phase 1: TEU Research, Design and Manufacture at the ERRDC

In January 2009, ONR begins preparations for TEU research and design at the ERRDC. ONR contacts the engineering departments at Villanova and Drexel University and invites faculty to meet with ONR researchers assigned to the ERRDC. ONR also arranges meetings with individuals performing related research in the pharmaceutical industry. During the meetings, ONR, faculty, pharmaceutical researchers and process engineers discuss the laboratory specifications and other specialized requirements for TEUs that will house laboratories. ONR and faculty researchers also discuss approaches that could be used to coat and seal the TEUs against potential environmental contaminants.

Attracted by the US Navy Office of Naval Research's (ONR) R&D collaboration with local universities and pharmaceutical companies, companies and entrepreneurs begin to express interest in a PNSY location. In response, PIDC forms the collaborative group Naval Yard Network (NAVYNET) and invites representatives from Select Greater Philadelphia, the Pennsylvania Department of Community and Economic Development, and ONR to join efforts to attract businesses. Through NAVYNET, PIDC recruits businesses that want to work in proximity to the ERRDC. In addition to one-on-one meetings with interested businesses and entrepreneurs, NAVYNET organizes happy hours and a softball league for existing PNSY tenants. These events increase the opportunity for informal networking and collaboration among the ONR, university, and business researchers who work at the Yard. NAVYNET also arranges internships between Villanova and Drexel University students with the ONR research project and with related businesses located at the Yard.

Once prototype research begins, the ONR prepares for TEU manufacturing. The ONR leases warehouse space with attached offices for research staff at the yard. The buildings are updated. Operation and maintenance procedures are implemented so that the site will comply with the Leadership in Energy and Environmental Design (LEED) standard for Existing Buildings. This renovation is another example of PSNY's leadership in

environmental initiatives and sustainable design. To ensure availability of a trained workforce for the TEU manufacturing, ONR meets with the Philadelphia Workforce Development Corporation.

Phase 2: Emergence of the Environmental Remediation Business Cluster

Environmental remediation removes pollution or contaminants from soil, groundwater, sediment, or surface water in order to protect public health or to prepare a Brownfield site for redevelopment. Remediation of a contaminated site increases a city or region's natural resource endowment of productive land. Potential benefits include increased property values, enhanced health and safety, reduced environmental health risks, jobs for local residents, revitalized neighborhoods, and a stronger municipal tax base.

At the end of 2009, the environmental remediation and consulting firm React Environmental Professional Services Group (React) opens an office at the PNSY. React's reputation as a leader in the field combines with the state-of-the-art laboratory research conducted at ONR's ERRDC to attract other environmental remediation service businesses to the Yard.

Having already established links between the ERRDC and universities; and between ERRDC and pharmaceutical companies, NAVYNET begins to organize networking events and recruits internship candidates for React and the other environmental remediation businesses. Invited to join NAVYNET, React enhances the networking opportunities available at the cluster by tapping into its professional relationships with community development corporations and other nonprofits that serve communities near Brownfields. With NAVYNET as the interest champion and React as the anchor firm, an environmental business cluster begins to develop at PNSY.

Philadelphia has a large inventory of Brownfield properties. Although the exact number is not known, the University of Pennsylvania's Cartographic Modeling Lab (CML) has started a GIS inventory and has completed the inventory for sections in North Philadelphia and along the Delaware River. In 2010, CML receives funding from the Pennsylvania Environmental Council to complete the Brownfield inventory. At the same time, higher gasoline costs and reductions in the city business tax combine to generate interest in low cost land in Philadelphia.

With better information, entrepreneurs and nonprofit organizations start to plan businesses and projects that can be located on remediated land. This activity increases the demand for environmental remediation services. React and the other firms at the PSNY are well positioned to meet that demand. React has a history of working with community and environmental nonprofits and this reputation attracts business to the cluster. At the same time, NAVYNET efforts are cultivating informal contacts and discussions with ONR staff and their academic and business counterparts. As a result, the cluster businesses begin to establish a reputation for their state-of-the-art approaches to environmental remediation.

Later that year, Philadelphia and the Commonwealth of Pennsylvania partner to fund remediation of all the Superfund sites identified when the CML inventory is complete. This project is part of a long-term marketing strategy to attract economic development and a skilled workforce to the city and it builds upon the momentum generated by CDC and other entrepreneurial activity around Brownfield development.

In 2012, EPA increases the funds available through its Brownfield grant program and accelerates efforts to clean up the remaining Superfund sites in the Mid Atlantic region, which includes the District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. The increased availability of federal funding adds to the demand for environmental remediation services in Philadelphia and throughout the Mid Atlantic region. More businesses open offices in the PSNY environmental remediation cluster. Municipalities throughout the region know about the PSNY's reputation as an environmental remediation hub and contact companies for innovative approaches to remediation.

University participation in the cluster increases along with the demand for environmental remediation services. Inspired by their contacts with ONR, ERRDC staff, and members of the business cluster, Drexel and Villanova establish their own remediation research facilities at PSNY. Philadelphia University's Sustainable Design program opens an atelier that features student designs for redeveloped Brownfields. Temple University partners with EPA's "Green Remediation" program to conduct demonstration projects. For these projects, Temple faculty and students work with EPA staff to remediate Brownfields in ways that use natural resources and energy efficiently, minimize pollution, and reduce waste.

Full service remediation businesses continue to establish themselves at the cluster. They are accompanied by companies that specialize in the physical tasks of environmental remediation such as asbestos removal, soil removal, and waste management. In addition to the benefits of working closely with other remediation businesses, these companies have access to a high quality workforce trained through Philadelphia's "Green Collar" workforce development program.

Municipal infrastructure and quality of life factors contribute to the business cluster's momentum. The SEPTA transportation network expands to improve access to the Navy Yard. Clients and staff of the PSNY businesses have access to frequent rush hour hybrid bus shuttles between the major regional rail stations and the PSNY. The city continues to phase out the business privilege and net profits tax, creating a more attractive climate for all small businesses. At the same time, more people are moving to the city, attracted by shorter commutes and lower housing costs.

The high level of environmental remediation activity continues for several years. Working in close proximity to the businesses, the ONR ERRDC and the EPA Green Remediation project, university researchers develop the practical applications of their research. The environmental remediation cluster expands to include businesses that develop and market the products that result from university research of the chemistry,

biology and engineering of remediation. The PNSY achieves a reputation for state-of-the-art technologies to extract and remove contaminants from soil and water and to transform the contamination into a harmless, and sometimes useful, material.

This case study envisions how a DOD contract will function as the catalytic converter that harnesses area assets and latent talent to achieve long-lasting economic growth and benefits. In this case, the ONR's research and development activities triggered the formation of the NAVYNET. This alliance of state and local economic development organizations has the interest and the resources to promote business cluster development. React's relocation to the PNSY fills the anchor firm role and establishes the environmental remediation presence at PSNY. From the very beginning, ONR's consistent outreach to local universities ensures their interest and involvement with the business cluster. Other success factors include financial and political support of federal, state, and local government and their expanding role as a client for environmental remediation services. The city's "Green Collar" workforce development efforts is another contributing factor. Philadelphia's transportation infrastructure and low cost of housing are quality of life factors that support cluster development. The early and strong university participation lays the foundation for a process that converts bench science into marketable products. This product development will continue to drive the cluster after the inventory of Superfund and Brownfield sites is depleted.

Appendix 7: Emergency Response Decontamination System Implementation Plan

Phasing concept detailing a three-phased scalable emergency response to an at-sea CBRN event.

Expand CBRN Training

- Identify members of the US Army CBRN School and US Navy who will sit on the Navy CBRN Training Committee. The committee's purpose will be to implement expanded training for specific CBRN procedures and roles for Navy damage control personnel and to define the requirements of a specific rating for personnel who can respond to a CBRN contamination.
- Convene CBRN Training Committee
- Establish meeting schedule, identify deliverables and set timeline for proposal to implement augmented CBRN training for DC personnel.
- Review training proposal recommendations
- Select recommendations for implementation
- Establish timeline for implementation of recommendations.
- Implement training recommendations.
- Execute Training and Exercise Program among stakeholders to include table-top exercise for proof-of-concept, and to incorporate lessons learned and concept improvements.

Integrate CBRN Procedure Components into Ship Design

- Identify members of the US Navy who will sit on the CBRN Integration Into Ship Design Committee
- Convene CBRN Integration Into Ship Design Committee
- Develop procedures to include CBRN processes within existing Navy systems such as the Joint Warning and Reporting Network (JWARN), in conjunction with the Hazardous Material Information Resource System (HMIRS) and in conjunction with Ship Class Database and the Joint Acquisition CBRN Knowledge System (JACKS).
- Establish meeting schedule, identify deliverables and set timeline for the final document that describes procedures and schedule for CBRN integration.

Develop Twenty-foot Equivalent Unit (TEU) concept and describe the decontamination response using a shipping container supply system.

Conduct Research and Planning for Physical Prototypes of TEUs.

- Prepare design and written specifications for TEUs.
- Research and specify the lab equipment and other specialized requirements for laboratory TEU components.
- Conduct research and planning to quantify the methods used to cover and seal the TEUs against potential environmental contaminants while maintaining a hospitable interior environment.
- Research TEU manufacturers.
- Select TEU manufacturer(s) for project.
- Evaluate and select shipyard location(s) for TEU storage.
- Meet with representatives of local workforce development corporation to plan availability of trained workforce for TEU manufacture.
- Coordinate any necessary manufacturing training with workforce development and union officials
- Assess access to air, land, and sea transport for TEUs.
- Locate warehouse with attached offices for engineering staff.
- Prepare portfolio of predesigned maps for assembling customized TEU networks
- Construct physical TEU prototypes
- Test and adjust prototypes
- Produce blueprints for individual TEUs based on feedback received from the prototypes already created.
- Fabricate and/or modify TEUs. When necessary, perform additional sealing and install environmental controls to transform TEUs into modules for the decontamination platform

- Evaluate potential vessel delivery options for the Phase III response and select the best of the following three options:
 1. Retrofit existing Commercial or Navy Vessel (Individual or Ongoing Usage)
 2. Construct a Specialized DOD Vessel
 3. Use Existing Commercial or Navy Vessel Without Retrofit

If Option 1 is selected, identify existing vessel and contract for retrofit and negotiate lease terms.

If Option 2 is selected, prepare RFP to design and build the customized vessel.

If Option 3 is selected, identify existing vessel and initiate purchase or requisition procedures.

- Design training program for TEU personnel
- Identify TEU personnel candidates from the Navy, Marine Corps, FBI, CIA, EPA and the FDA.
- Finalize the four pre-positioning locations
- Develop detailed timeline for 8-10 year rollout of the Philadelphia node.

Reach-Back and Research Component.

Create a one-stop Operations Center to respond to and coordinate response to a CBRN event anywhere that the Navy operates

- Convene DHS and DOD stakeholders to select the most appropriate Operations Center site from existing locations.
- Develop procedures for communication between the expanded Operations Center and the Emergency Response Research and Design Center (ERRDC).

Establish a design, fabrication, and maintenance facility for the modular TEU units that this project will use extensively

- Lease warehouse space with attached offices for research staff.
- Update buildings.
- Implement operation and maintenance procedures for the manufacturing site.
- Purchase/lease and install manufacturing equipment.
- Meet with local workforce development organization to ensure availability of trained workforce for manufacturing.

Develop a dedicated research and innovation cluster that draws together DOD personnel, university and other researchers, and the private sector

- Convene ONR stakeholders to select location for the ERRDC.
- Convene working group of key local government and research institution stakeholders and US Navy personnel to determine locations for ERRDC where reach-back and research activities will take place.
- Identify individuals performing similar research at local businesses and universities.
- Set up meetings between ERRDC researchers and business and faculty researchers to discuss:
 - Laboratory specifications
 - Other specialized requirements for TEUs that will house laboratories
 - Approaches to cover and seal the TEUs against potential environmental contaminants.
- Open and staff the ERRDC
- Identify local and state groups that have the interest and resources to promote business cluster development around the ERRDC research site.
- Create business cluster interest champion by forming alliances with local and state economic development groups.
- As member of interest, champion alliance, work to recruit anchor firm for cluster, build relationships with local universities and investigate how local, state and/or federal government can step into the role of partner, investor, client and/or provide infrastructure improvements.
- As member of interest champion alliance, identify and recruit major environmental remediation firm to anchor of the business development cluster.

Appendix 8: Emergency Response System Case Study

I. Purpose Statement

This pre-mortem will act as a model for potential circumstances absent TTPs specifically applicable to the proposed scenarios. The goal of our test case is to validate assumptions made in the design phase of both the hard and soft elements of the project. This modeling should serve as a precursor to additional modeling to be performed on the technical components of the plan and in anticipation of future 'Flight 0' studies.

II. Situation

In the next 20 years the United States and the Navy will be confronted with multiple threats bearing weapons of varying composition and force.

China declares right to a territory for which it traditionally has no claim. In the past, such moves occasionally drew censure from the international community but were mostly ignored. With energy resources dwindling, such oversights are no longer possible. Under international pressure to retract their false territorial claims, China makes a grab for the one remaining locales for which they have a traditional stake: Taiwan. Chinese naval vessels steam from ports across the Chinese mainland. With a substantial force put to sea, China seeks a blockade of Taiwan followed by ground invasion.

An ad hoc mix of Type 956 Russian-built *Sovremenny*-class and Chinese *Luhai*- and *Luhu*-class destroyers form a loose but efficient blockade. Alone, they are inferior by Western standards. However, they are joined by a potently armed pack of diesel-electric and nuclear powered submarines from the *Song*-, *Han*-, *Xia*-, *Shang*-, *Jin*-, and Russian *Kilo*-classes. Additional surface support is provided by the snub-nose of the growing fleet, Type 053 *Jianghu*-class frigates and *Houxin*-class missile boats. While the PLA is backstopped by millions of volunteer and conscripted soldiers, the PLAN is limited by capacity and must rely on additional strategic and tactical factors.

Despite a fleet of ships that is not comparable to the United States or other Western powers, the armaments deployed are largely Soviet or Russian origin and designed specifically to counter the AEGIS weapons system deployed aboard U.S. warships. To increase their reach and effectiveness, the PLAN has unsealed hundreds of chemical and biological munitions to serve as a deterrent and/or force multiplier.

Honoring treaty obligations, the United States responds to Taiwan's call for assistance. Orders are issued to SOCOM forces worldwide. PACOM is ordered to DEFCON 3. Despite official protests from the United States, Taiwan and most of the European powers, China remains undeterred. The blockade is at full force within days. Diplomatic efforts at the United Nations fail to yield results. PACOM moves to DEFCON 2.

Efforts to break the stalemate through diplomatic means have thus far proved unsuccessful. U.S. Naval forces are ordered to divide the blockade from the mainland; the maneuver breaks PLAN supply lines and isolates the largest components of the surface Fleet from their home ports.

U.S. forces have essentially blockaded the blockade force and frustrated Chinese political leaders and prevented full-scale invasion. The PLAN responds with ratcheted aggression, ordering their *Kilo*- and *Song*-class SSNs to bracket U.S. warships in the Strait.

Chinese shore-side missile batteries go live with stationary and mobile launch platforms gearing up to launch a rain of ordnance into Taipei. As the Chinese shore batteries open up, the U.S. Fleet responds with waves of interceptors.

To the conventionally armed JH-7s already airborne, the PLAAF begin to arm units on stand-by with YJ-81s carrying a chemical payload. They also load a mix of Q-5s with dedicated chemical or HE 250kg bomb payloads. No longer a deterrence asset, chemical weapons are being prepared for battlefield use.

J-11s from Suixi AB in South China launch a strike mission targeting Kaohsiung along Taiwan's western shore. F/A-18s and F-35s scramble from the battle groups positioned East and South of Taiwan on a deterrence mission. Though numerically inferior, the Chinese aircraft press on for Taiwan.

U.S. combined air power responds with B-1 and B-2 strikes on shore batteries of surface-to-surface missiles and two-ship formations of F-22As penetrate Chinese radar and strike tac-air assets in-country, withdrawing without detection. The Chinese stand-up all shore side batteries and prep for a phased barrage against Taiwan. Anticipating U.S. countermeasures to the missile strike, all Chinese aircraft are set to launch. The PRC issues a final warning to the U.S. and its allies. When U.S. assets do not withdraw, missiles launch.

The first phase of missiles is away. Battleships are tracking and destroying inbounds, plotting firing solutions and prosecuting counterstrikes. The shipboard self protection systems destroy most inbound missiles and the standard Sea Sparrow suite engages incoming bomber aircraft. While sections of some ships are struck by debris, there are no direct hits.

The last phase of Chinese conventional ground-launched missiles is away. Remaining PLAN and PLAAF assets with mixes of conventional and chemical munitions launch and target the same centers of gravity. This time the multitude of simultaneous functions prevents complete denial. Chinese sea-skimming ASMs find their targets. Aircraft laden with HE and chemical-tipped YJ-81s launch against the starboard side of a 51-class DDG, two missiles impact the ship. The first, loaded out with a 165kg semi-armor piercing HE warhead, strikes aft of the first engine compartment less than 2m above the waterline. The second missile impacts just forward of the first, broadside, above deck.

The destroyer is damaged, with a Class Bravo fire burning between engine compartments, fed by a sheared JP-5 line. Related explosions have caused Class Alpha and Charlie fires in adjacent areas. The impacts of the two chemically charged missiles,

however, are potentially more lethal. Using armor piercing warheads, both the missiles penetrate the lighter armor and discharge internally, rapidly filling adjacent compartments and deck areas with gaseous and liquid forms of a highly lethal and persistent chemical warfare agent. Decisions made in the hours to come are critical.

III. Procedure

The ship, already isolated into general quarantine (GQ), begins working through its internal procedures. In any damage control situation, preserving the watertight envelope of the ship is first priority. Second priority is to ensure buoyancy. Third priority is to eliminate hazards that threaten the vessel. Damage remediation is the last priority.

IV. Phase I

Damage Control Teams don gear and gather at their damage control stations. Within 10 minutes of the first impact, the decks below the waterline are sealed and hatches dogged down; the ship is compartmentally sealed, bow to stern. Investigators sweep fore and aft, deck-to-deck in search of damage.

Crewmen locate a hull breach between second and third decks on starboard, amidships. With a JP-5 line pierced, a fire rages in the compartments and aviation fuel threatens catastrophic damage. Quick action prevents additional fuel spillage and fire teams prepare to take down the Class Bravo with onboard AFFF supplies. The fire is contained and fully extinguished in a matter of minutes. Sea water has flooded into the affected compartments but it is containable. The affected compartments are sealed and the watertight envelope is preserved.

A second team locates secondary and tertiary damage points five and seven frames forward, which have penetrated the main deck and second deck. The team detects a Class Charlie in addition to a small scale Class Alpha fire. Both fires are handled within minutes utilizing the SOP for damage control operations.

The ship continues to transit out of harm's way under its own power but with two cruiser escorts and continuous overfly. Once it has cleared the littorals, the damage control assessments reveal the presence of chemical agents. What was once just a damaged hull is now a mortal hazard.

The bridge initiates contact with Fleet command through the battle group and up the chain. The CO's assessment is that the ship is stable but the level of contamination cannot be determined. Following Fleet procedures for chemical weapon contamination, the CO requests a decontamination assessment team. The Fleet approves and the CONUS and Outside the Continental United States (OCONUS) assets begin to spin-up.

V. Phase II

The decontamination elements' Deuce ALPHA and BRAVO components go hot. All personnel from the CBIRF component are immediately recalled and the assets readied for immediate departure to the incident scene.

Deuce ALPHA or Phase II 'Alpha' will be the first external response unit on scene. With the crew onboard and Fleet escorts having performed those tasks necessary and required to secure the vessel and its watertight envelope, personnel begin to triage casualties and provide primary intelligence on the vessel and its contaminants, the airborne element will provide specialized expertise in CBRN detection, decontamination and protection. A *Wasp*-class LHD (amphibious assault ship) provides interim overwatch for the vessel and will also serve as a launch and recovery site for 35Bs and MV-22s.

Within 24 hours of the attack, the airborne ALPHA element deploys aboard five Ospreys – four containing 22 personnel and 2,000 lbs of cargo each and the fifth loading out with up to 10,000 lbs of cargo and supplies. Because of the unique capabilities of the MV-22, it deploys from CONUS and traverses directly to the *LHD*.

While the ALPHA component deploys to the incident scene, BRAVO team transits to the AOR to accept its assets and run pre-deploy checks on their equipment. Although one stock of the system is pre-positioned in Guam, the Diego Garcia unit has better tactical advantages. BRAVO sets to sea aboard a fast response vessel to be determined with its standardized set of core response capabilities that provide a command and control structure and the tools necessary to commence full-scale personnel decontamination operations.

As Deuce BRAVO elements deploy, Phase III assets are already going hot. When the ALPHA *Ospreys* set down on the LHD, TEUs are prepping to roll onto a Phase III response vessel.

Deuce ALPHA A/C 01 arrives first on scene, transferring manpower aboard the LHD to two waiting *Seahawks* for immediate transfer to the affected ship, enabling the new scene commander to embark. The first team, the Recon Element consists of the following:

- Recon Component, 18 (10 Enlisted, 7 Corpsmen and 1 Medical Officer)
- Support Component – HQ, 2 (1 Enlisted and 1 Officer)
- Security Component, 2

Recon coordinates arrival of the other team components, locates the HQ element, and detects, classifies and identifies the contaminant. If they are unable to identify an agent with their equipment, members collect samples for available agencies to identify.

Deuce ALPHA A/C 02 carries the Decontamination Element consisting of the following:

- Decontamination Component, 18
- Support Component – HQ, 2 (1 Enlisted and 1 Officer)
- Security Component, 2

Decon pre-stages aboard the LHD in the helo hangar.

Deuce ALPHA A/C 03 carries the Medical Element consisting of the following:

- Medical Component, 10 (7 Corpsmen and 3 Officers)
- Support Component – HQ, 2 (1 Enlisted and 1 Officer)
- Security Component, 2
- Support Component – Supply, 2

Med Element likewise pre-stages in the LHD Hanger deck.

Deuce ALPHA A/C 04 embarks the Support Element consisting of the following:

- Support Component – HQ, 4 (2 Enlisted & 2 Officer)
- Support Component – Supply, 2
- Support Component – Engineering, 3
- Support Component – Embark, 6
- Security Component, 7

Support element utilizes deck space to the degree necessary to hold equipment.

Deuce ALPHA A/C 05, the Cargo Element, is unloaded and equipment stowed below deck.

VI. Phase III

ALPHA Recon meets first with the vessel CO and begins a complete assessment of conditions onboard. Once the element achieves full situational awareness, the scene commander determines if the condition of the ship and the status of the crew warrants a Phase III D response. With a physical hull breach, the scene commander cannot certify that a temporary repair to the outer watertight envelope can be sustained until port call in CONUS. The order is sent and Phase III personnel and kit deploy directly to the affected DDG as it continues under its own power toward Diego Garcia with its escort vessels. A heavy lift vessel is en route to Diego Garcia and the pre-po stocks there and in Guam go fully hot.

Phase III assets hop to the LHD where they are transferred to the DDG via *Seahawk*. The scene commander withdraws unnecessary Phase II forces, mainly security and support components and prepares to return Command and Control to the affected ship's bridge for the remainder of the time at sea prior to rendezvous with the heavy lift. The ship CO and XO, unaffected by the chemical agents present onboard and testing negative, resume command of the vessel with continued close monitoring from the decon and med elements of Phase II, who will remain aboard to monitor conditions.

By D-Day +21, the contaminated ship is loaded aboard the heavy lift ship. The Damage Control teams have buttoned up the contaminated areas and sealed ventilation and transit spaces. The contamination is effectively contained to the immediate impact zones, the deck adjacent to the impact zone, the ventilation system and spaces one deck above and one deck below the immediate impact areas. Transit fore and aft is still possible by port side corridors, though less convenient.

A U.S. repair facility cannot accept the ship in its current condition. The chemical contaminants must be cleared. The exterior must be fully remediated. Internal spaces require only a mid-level decontamination prior to arrival at the repair yard. Mid-level decontamination is defined as containing all contaminants and ensuring that human exposure poses an acceptable risk, though special categories of population may experience deleterious effects with long-term exposure.

The decontamination solution that performs most optimally against the VX-like agent is a Vaporized Hydrogen Peroxide (VHP) solution. Please note the attached Army study on VHP decon compounds. Due to the complex textures and facets within a DDG, the decon process is painstakingly slow and it is difficult to remove contaminated materials given the tight quarters. However, the trunk wells provide sealed access to and from the contaminated area and serve as dedicated toxin removal corridors. Since these spaces are designed to be free of clutter, they require less decontamination after materials are removed through that space.

The ventilation system presents the most difficulty. Teams utilize chemical detection equipment in every space serviced by the affected ventilation system and recirculation lines to determine the extent of exposure throughout the vessel before, during and after the removal and replacement of those lines. Upon the satisfactory removal of all directly contaminated equipment and resealing of hot zones, the decon team uses its VHP mixture to essentially steam-clean the ship's innards.

VII. Case Study Conclusions

Satisfactory completion of the VHP phase with continued monitoring ensures that the ship will be accepted at the repair dock and will prevent public outcry in response to the mooring of a highly toxic vessel. The ship is decontaminated to a mid-level state. A very rough estimate of the total cost of decontamination would be less than \$20 million to develop and deploy a baseline decon capability. By comparison, the estimated cost to build a ship comparable to the *Zumwalt* is \$1.4 billion.

Appendix 9: Clusters, Development and the Power of Agglomeration

Since the mid-1990's, the identification, growth and leveraging of clusters has been the hallmark of workforce and industrial development. The following key characteristics define these clusters:

- Complementary industries
- Systematic relationships
- Geographically bound
- Life cycle driven

By using a cluster approach and determining the disparate types of industries that are needed for the project, the DOD can integrate nationally renowned technical science programs³⁰⁸ – mechanical, nuclear, aerospace, industrial, manufacturing, electrical, computer and computer science engineering and robotics – to develop answers to these complex problems associated with consequence management, decontamination and remediation.

Clusters are not a new idea. Beginning in the Renaissance, and for centuries after, much of the woven silk fabric came from a single neighborhood in Venice³⁰⁹ where the weavers originally gathered around a large family-owned business, which would be known today as the anchor firm. Spinoffs resulted with specialty and subspecialty firms operating in niche markets. Specialization, resource access, informal knowledge networks and a skilled labor pool created a substantial competitive advantage over similarly sized firms located in other parts of Europe. Similar clusters developed in the United States beginning in the early 19th century. Examples include the establishment of Fabric Row in Philadelphia, Wall Street in New York, steel production in Pittsburgh, chemical manufacture in Delaware. These clusters experienced the same advantages that enabled the Venetian cluster to dominate the woven silk fabric industry. A more recent example is the growth and development of Silicon Valley that arose from the combination of the California population and defense spending boom. Silicon Valley, together with its countless imitators (Silicon Alley, Silicon Fen, Silicon Glen, Silicon Hills, and Silicon Desert among them), demonstrate that clusters continue to thrive and counter-intuitively may have an even greater impact in our high technology world than they did in the past.

Despite the long history of cluster success, several questions remain for economic developers and strategists: Can government, business, or universities intentionally create, grow and sustain clusters? If these institutions, acting singly or jointly, can create and sustain clusters, what actions are needed to do so? If institutions can create and sustain clusters, what lessons are to be learned for our proposed phased response system and the R&D and manufacturing functions inherent to its success?

³⁰⁸ Ibid.

³⁰⁹ Lesser, Guy "Keeping a Tradition Alive: Venice's Silk Weavers" International Herald Tribune August 17, 1993

To answer these questions, an analysis of a series of regional clusters throughout the United States is presented below in case study form. While it is always hard to define the boundaries of a cluster, there are some common elements:

- A high level of R&D performed inside the geographic boundaries of the cluster
- Wages that are higher than average for the respective Metropolitan Statistical Areas (MSAs)
- Higher levels of educational attainment
- A significant number of firms and employees in the lateral complementary specialties that are geographically linked in a way that allows close collaboration and cross pollination of ideas and practices as employees move among firms.

In the case studies presented here, the clusters were conceived in many different ways with an array of situational and practical parents. For example, Houston's oil and gas industry cluster developed from a natural resource endowment that required constant monitoring and maintenance. By contrast, Pittsburgh's Life Science Greenhouse arose out of a conscious government effort to leverage local assets to create jobs and investment in an area reeling from years of disinvestment and job loss. In North Carolina, Research Triangle Park was the result of a university idea brought to life by a private developer that the universities approached.

Regardless of how a cluster is born, the case studies illustrate several factors that must be present in order for the clusters to survive and thrive. The factors are³¹⁰:

- Natural Resource Endowment and/or Interest Champion
- University Involvement – In most clusters the local university(ies) plays the key role.
- Anchor Firm - One or several firms that are large enough to create spinoffs and are involved enough to act as interest champion or to play a close supporting role
- Networks/Collaboration - The cluster succeeds or fails based on informal networks such as softball games and lunch gatherings as well as more formal linkages cultivated by employee transfer, partnerships and cluster-based cooperative marketing and idea exchanges
- Government Involvement – Governments support the cluster as clients, partners, and investors, and most importantly, as providers of infrastructure and quality. Governments also need to provide low regulatory interference and higher than average quality of life to attract and retain employees

When the case studies are evaluated for their applicability to the proposed R&D cluster, the case studies of Research Triangle Park and the Life Science Greenhouse in Pittsburgh demonstrate that not all factors need to be present in order for a cluster to thrive. Research Triangle Park had little if any natural resource advantages at its conception and limited technological or research in the area upon which to draw. In addition, the cluster site was a tightly defined space smaller than Philadelphia's

³¹⁰ Factors cited are a distillation of several sources including Michael Porter's corpus of work, the US Economic Development Agency Reports, The Presidents Council on Global Competitiveness, and the ongoing work of the Stanford Institute for Economic Policy Research.

Fairmount Park and not much larger than the proposed Navy Yard site. Pittsburgh's Life Science Greenhouse was the result of an overarching study of local assets that were then rebranded and focused with relatively modest government start up funding.

Software Technology Route 128 – Boston, Massachusetts

Establishing the nation's largest software technology cluster was not part of the Route 128 design plan. It was constructed simply to circumvent Boston. However, the city's historical attraction for inventors, its access to skilled professionals and research funding, and physical infrastructure combined to create the software development industry cluster along the Route 128 corridor.

Boston has a historical attraction for inventors. By the mid-19th century, the city had a national reputation as a center for technological innovation, and attracted many inventors and professionals who were seeking opportunities to expand in their fields.^{311 312} Over the years, several industries established themselves in the region, including the auto industry, telecommunication, and minicomputers. However, each of these industry clusters eventually relocated to other cities like Detroit, New York, and Silicon Valley, respectively.³¹³ In spite of these losses, the Massachusetts economy continues to recover, due in part to the strong influence of MIT and other universities, which make a significant contribution to the area's high level of education, large number of start up companies, and elevated per capita patent rates.

Route 128 was built in the 1920s to eliminate traffic congestion. The area attracted businesses from the very beginning. Real estate agents and corporations recognized the corridor's growth potential due to the availability of land and easy access to universities and other research bases in the city.³¹⁴ Raytheon was already located along the 65-mile highway span in 1951 when the state expanded the strip and additional industrial parks were built around it. The Federal Government's post World War II provided large amounts of research and development funding to universities and the technology industry, which increased the number of skilled professionals in the region.³¹⁵ In the 1970s and 1980s, funding from the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) supported high technology and led to the creation of a minicomputer industry.³¹⁶ However, faster innovation and a younger,

³¹¹ Manning, Kenneth R. Nov. 21, 2005. "The Culture of Invention in Boston" Accessed on Nov. 26, 2007 via <http://edison.rutgers.edu/latimer/cultinvt.htm>

³¹² Boston History and Innovation Collaborative. Accessed on Nov. 26, 2007 via www.bostoninnovation.org

³¹³ "Boston's Lessons in Sparking Innovation." Bob Krim and Janey Bishoff August 24, 2007. The Boston Globe. Accessed on Nov. 26, 2007 via http://www.boston.com/news/globe/editorial_opinion/oped/articles/2007/08/24/bostons_lessons_in_sparking_innovation/

³¹⁴ Mass Moments. Accessed on Nov. 14, 2007 via <http://www.massmoments.org/moment.cfm?mid=246>

³¹⁵ "Refining the University-Industry Relationship for Manufacturing Excellence." Eager, et al. September 20, 1993 accessed on November 21, 2007 via <http://eagar.mit.edu/EagarPapers/Eagar146.pdf>

³¹⁶ Mass Moments. Accessed on November 14, 2007 via <http://www.massmoments.org/moment.cfm?mid=246>

highly skilled workforce in California drew the minicomputer industry away from the Boston area.

The study of The Silicon Valley cluster consists of more risk-taking, start up businesses, and Saxenian (1995) identifies that a “distinguishing feature of the Silicon Valley economy is its unparalleled rates of new firm formation....In 1992, for example, some \$800 million in venture capital investments went to 152 Silicon Valley start-ups out of a pool of \$2.5 billion invested nationwide.”³¹⁷ On the other hand, the Boston region produces more stable, centralized corporations. Of the historical leaders of the region, Campbell (1995) says “...their ethic of work and their emphasis on authority and prudence still influence New England's communities.”³¹⁸ Alan Earls attributes the differences between Silicon Valley and Route 128 to the fact that in Boston “...firms had become entrenched, had sought to foster loyalty and long-term commitment in their employees, and so on, because that was the key to their success up to that point.”³¹⁹ In stride with the Boston culture of loyalty, Massachusetts laws gives businesses more power to contain employees than other states.⁹³ Massachusetts also has less government restrictions on the software industry than other states, causing the return of businesses and skilled professionals to the Boston area.³²⁰ Other cultural attractions like parks, museums, and the maritime industry, along with more room for residential expansion has been drawing companies away from the Silicon Valley.³²¹

Although the minicomputer industry relocated to the West Coast, the presence of MIT and Harvard, combined with the previous establishment of the computer industry makes this region extremely attractive to new businesses. MIT, in particular, has played a leading role in the growth and establishment of the software industry by providing students with the skills necessary to build and sustain companies in the area.³²² The university's founding philosophy of “learning by doing” established a practical, academic culture in the region that has been a key factor in the success of Route 128. MIT was established by William Barton Rogers in 1861 with the goal of industrializing the region. His vision was to teach and encourage students to use scientific knowledge they learned in classes and apply it to industries of interest.⁹⁷ Professors are encouraged to teach current problems of industry, encouraging students to understand and solve problems they might encounter after graduation.³²³ MIT also supports networking and retaining close ties between professors and students, so that advice and expertise of MIT faculty

³¹⁷ Saxenian, AnnaLee. “Creating a Twentieth Century Technical Community: Frederick Terman's Silicon Valley.” November 1995. Accessed on Nov. 28, 2007 via <http://people.ischool.berkeley.edu/~anno/Papers/terman.html>

³¹⁸ Campbell, John. “Mid-life Crisis on Route 128” Regional Review. Summer 1995, vol. 5 issue 3

³¹⁹ “Watching the Rise of Route 128, the Road to Nowhere” Interview with Alan Earls. From Newslink, Vol. 7, No. 2, Winter 2003.

³²⁰ “MIT: The Impact of Innovation.” March 1997, Bank Boston. Accessed on Nov. 21, 2007 via <http://web.mit.edu/newsoffice/founders/Founders2.pdf>

³²¹ Saxenian, AnnaLee. “Creating a Twentieth Century Technical Community: Frederick Terman's Silicon Valley.” Nov. 1995. Accessed on Nov. 28, 2007 via <http://people.ischool.berkeley.edu/~anno/Papers/terman.html>

³²² Etzkowitz, Henry. 2002. MIT and the Rise of Entrepreneurial Science. Routledge; London

³²³ “MIT: The Impact of Innovation.” March 1997, Bank Boston. Accessed on Nov. 21, 2007 via <http://web.mit.edu/newsoffice/founders/Founders2.pdf>

and other supporters can help graduates' businesses survive.³²⁴ The MIT Industrial Liaison Program, which allows alumni to tap into faculty and staff research to support technological and managerial innovation, is another academic resource that helps attract skilled labor, and innovation³²⁵

Currently, about 150 companies with MIT connections are established each year.¹⁰⁰ The largest portion of these companies is in the electronics industry, which includes computers, semiconductors, instruments, telecommunications equipment, and electrical machinery. Other industries that attract MIT startup companies are software and engineering consulting.³²⁶ Although less than 9 percent of MIT students are from Massachusetts, 45 percent of MIT-related companies are located in the Boston area, which suggests that graduates prefer establishing their entrepreneurial efforts in the region. University access has a strong influence on the entrepreneurs among MIT graduates. In a Bank Boston survey, MIT alumni stated that proximity to the University has a greater influence when choosing to start a company than any other business cost.³²⁷

Access to a skilled workforce is another important factor to consider when founding a company. In 2005, 37 percent of the Massachusetts labor market had at least a bachelor's degree, placing it 10 percent higher than the national average.³²⁸ In Boston, approximately 55 percent of the population has at least some college education.³²⁹ Patent activity also demonstrates the region's high level of education. In 2006, Boston led the nation in patents per capita, receiving 54 per 100,000 people.³³⁰

However, the cost of housing is beginning to exert its influence on the workforce. Massachusetts is experiencing an affordable housing shortage, and rising housing costs are driving residents from the region.^{331 332} Specifically, the Greater Boston area is experiencing a lack of workforce housing, i.e., single family homes for young families with children.¹⁰⁷ The Greater Boston Housing Report Card 2005-2006 states that "The lack of housing for this important market segment continues to discourage 25- to 34-year-olds from remaining in the region or moving here."¹⁰⁸ However, in 2006 Boston housing

³²⁴ Ballon, Marc "Entrée to Riches: Winning at MIT." March 1998. Accessed on Dec. 5, 2007 via <http://www.inc.com/magazine/19980301/882.html>

³²⁵ MIT Industrial Liaison Program. Accessed on Nov. 21, 2007 via http://ilp-www.mit.edu/display_page.a4d?key=H1

³²⁶ "MIT: The Impact of Innovation." March 1997, Bank Boston. Accessed on Nov. 21, 2007 via <http://web.mit.edu/newsoffice/founders/Founders2.pdf>

³²⁷ MIT Industrial Liaison Program. Accessed on Nov. 21, 2007 via http://ilp-www.mit.edu/display_page.a4d?key=H1

³²⁸ Speech by Susan Hockfield given on Sept. 14, 2005. Accessed on Nov. 26, 2007 via <http://web.mit.edu/hockfield/speeches/2005-chamber-of-commerce.html>

³²⁹ "Boston's Dynamic Workforce." Accessed on Dec. 3, 2007 via www.cityofboston.gov/bra/pdf/documents/20-34report.pdf

³³⁰ The Boston Indicators Project. Accessed on Dec. 3, 2007 via www.bostonindicators.org

³³¹ "MIT: The Impact of Innovation." March 1997, Bank Boston. Accessed on Nov. 21, 2007 via <http://web.mit.edu/newsoffice/founders/Founders2.pdf>

³³² "The Greater Boston Housing Report Card 2005-2006." Retrieved from www.bostonindicators.org on Dec. 5, 2007

prices did decrease—by 2 percent—for the first time since 1990.³³³ While this is an important trend, Massachusetts acknowledges the importance of creating more affordable housing and zoning to improve the quality of life for its residents.³³⁴

While collaboration between universities, industry, and government has led to successes within various industry clusters, the importance of regional factors is evident when studying the Boston software technology industry. Massachusetts is unusual in its ability to produce strong clusters throughout history, and research has attributed this capability to cultural elements. The recounting of regional innovation and invention has fostered a tradition of creativity while maintaining stability. MIT has also been influential in producing a skilled workforce, providing a strong compilation of business expertise, and building and retaining businesses for economic growth. While Massachusetts housing affordability is low, there have been slight improvements in the last year. The improvement in housing accessibility, along with the impressive workforce statistics and patent rates makes the Boston region well-suited for the software technology cluster.

Research Triangle Park – Raleigh-Durham, North Carolina

The Research Triangle Park (RTP) in Raleigh-Durham, North Carolina, was founded in 1959 in response to an economic crisis in the region.³³⁵ Private and state government leaders organized to address the lack of skilled employees and the area's low per capita income. Karl Robbins, a private investor, bought about 4,000 acres of pineland to begin the research center. The Pinelands, a for-profit company, became the first shareholder and helped recruit more investors and companies.³³⁶ The University of North Carolina and Duke University then became involved to form the Research Triangle Foundation, a nonprofit organization that runs the park. The landscape forms a triangular campus linking the University of North Carolina - Chapel Hill, Duke, and North Carolina State University. RTP is 7,000 acres, stretching 2 miles wide and 8 miles long.³³⁷

The Research Triangle Institute was the first company to locate in RTP.³³⁸ Since then, companies like IBM, GlaxoSmithKline, and government agencies like the EPA have established bases in the area, creating jobs in software engineering,³³⁹ statistical analysis,³⁴⁰ and biological and health sciences.³⁴¹ The opportunity for businesses to locate near large research universities and other companies gives RTP an advantage over clusters that are more spread out. According to Harvard economist Michael Porter, “geographic, cultural, and institutional proximity leads to special access, closer

³³³ The Boston Indicators Project. Accessed on Dec. 3, 2007 via www.bostonindicators.org

³³⁴ “We Can’t Afford Business as Usual” 2006 Massachusetts Housing Partnership Annual Report.

Accessed on Dec. 5, 2007 via http://www.mhp.net/uploads/resources/low_res_mhp_2006_ar.pdf

³³⁵ http://www.rtp.org/files/Fact%20Sheets/overview_presentation.pdf Accessed on Dec. 28, 2007

³³⁶ Link, A. N. & Scott, J. T. “The Growth of Research Triangle Park” Accessed on Dec. 28, 2007 via <http://www.dartmouth.edu/~jtscott/Papers/00-22.pdf>

³³⁷ http://www.rtp.org/files/Fact%20Sheets/rtp_general.pdf Accessed on Dec. 28, 2007

³³⁸ <http://www.rti.org/newsroom/page.cfm?nav=830> Accessed on Dec. 28, 2007

³³⁹ http://careers.peopleclick.com/Client40_GLDTR/bu1/External_Pages/Showjobs.htm Accessed on Dec. 28, 2007

³⁴⁰ <http://us.gsk.com/html/career/jobsearch.html> Accessed on Dec. 28, 2007

³⁴¹ <http://www.epa.gov/rtp/employment/index.htm> Accessed on Dec. 28, 2007

relationships, better information, powerful incentives, and other advantages in productivity and innovation that are difficult to tap from a distance.”³⁴² Transportation access is another advantage of the location. Research Triangle Park’s proximity to the Raleigh-Durham International Airport, several major highways and railways, and Wilmington and Moorehead City ports make it easily accessible.

Research Triangle Park was formed mostly by private interests and the government has played a minimal role in its development. Private sector groups decided that the concept behind the Research Triangle project idea was valid and should be undertaken as a private effort with participation of the three flagship universities rather than sponsored by the state or Federal government.³⁴³ Research Triangle Park has collaborated to form several organizations which maintain and promote growth within and among industries. The Research Triangle Foundation manages and develops RTP while regulating that the Park’s environmental and aesthetic dimensions are maintained.³⁴⁴ RTI International, originally the Research Triangle Institute, which was the first company in the Park, is currently a leading research organization that works to “harness the intellectual capital of the area’s three major universities.”³⁴⁵ RTI offers innovative solutions to governments and businesses in the fields of technology, health, education, economic and social development, and environmental issues. The Triangle Universities Center for Advanced Studies, Inc. (TUCASI) maintains and encourages university involvement in the RTP. TUCASI works with the three universities to oversee projects and research that will improve the status of RTP and the schools.³⁴⁶

When RTP was founded, private and academic local leaders wanted to improve North Carolina’s economy by creating higher paying jobs, increasing the level and quality of education, and reducing unemployment.³⁴⁷ Leaders also wanted to shift the local industrial focus from agriculture and manufacturing to research and technology. By positioning RTP between three major universities, the region was able to attract and maintain selective college students and graduates, increasing human capital in the state. Currently, 53 percent of the Raleigh-Durham population has earned a bachelor’s degree or higher.³⁴⁸ The Research Triangle Foundation also made a point to focus more on increasing capital than providing low wage employment for company profits. The RTP currently includes 157 companies and employs more than 39,000 individuals.¹²³ By

³⁴² Porter, Michael. “Clusters and the New Economics of Competition.” *Harvard Business Review* 76 (Nov/Dec.1998): 80

³⁴³ Weddle, R. L. “Summary of Remarks and Supporting Data Panel I: North Carolina’s Changing Economy”:4 Accessed on Dec. 28, 2007 via http://www.uscc.gov/hearings/2007hearings/transcripts/sept_6/rick_weddle.pdf

³⁴⁴ Weddle, R. L, Rooks, E. & Valdecanas, T. “Research Triangle Park: Evolution and Renaissance” June 2006. Accessed on Dec. 28, 2007 via http://www.rtp.org/files/Fact%20Sheets/rtp_history.pdf

³⁴⁵ <http://www.rti.org/newsroom/page.cfm?objectid=811D5426-8352-4177-AB05DDE414A36804>

³⁴⁶ Harden, J. Presentation on RTP, Dec. 30, 2005. Accessed on Dec. 28, 2007 via http://www.klv.nl/hulsink/Hardin_Presentation_Research_Triangle_Park.pdf

³⁴⁷ Weddle, R. L, Rooks, E. & Valdecanas, T. “Research Triangle Park: Evolution and Renaissance” June 2006. Accessed on Dec. 28, 2007 via http://www.rtp.org/files/Fact%20Sheets/rtp_history.pdf

³⁴⁸ Weddle, R. L. “Summary of Remarks and Supporting Data Panel I: North Carolina’s Changing Economy” : 4 Accessed on Dec. 28, 2007 via http://www.uscc.gov/hearings/2007hearings/transcripts/sept_6/rick_weddle.pdf

providing more than 40,000 housing units in the area, the Park has also made it easy for employees to access and live close to the center.¹²³

RTP holds a variety of cluster industries, including biotechnology and pharmaceutical sectors, information technology, professional and financial services, electronics, and environmental science.³⁴⁹ Twenty-nine percent of RTP companies are in the biotechnology and pharmaceutical cluster. Nineteen percent of the companies are in the information technology cluster and 16 percent are in the professional and financial services cluster. These industries continually compete within and between clusters to increase innovation and profits.

The RTP also facilitates informal networks, which cultivate personal relationships among companies and employees while supporting information sharing and a sense of community. For example, four softball leagues with eight teams each play recreationally.³⁵⁰ The league stresses that the games are not related to work, and that there should be minimal competition between teams. Twice a month, on “Techie Tuesdays,” employees from any company in the RTP can meet for drinks, socializing, and networking.³⁵¹ The RTP Owners and Tenants Association have also organized a Smartcommute association to help RTP employees carpool to work.³⁵² The Smartcommute program saves employees money and reduces traffic congestion and pollution in the surrounding areas. There are also several jogging and pedestrian trails for employees throughout the RTP.³⁵³

Research Triangle Park demonstrates that a cluster can thrive even when some of the success factors are absent. The location had no natural resource advantage and the interest champion, a consortium of private sector groups, wanted no government involvement. There were very few technological or research resources and opportunities at the outset. However, the presence of other success factors was strong enough to overcome these absences. The University of North Carolina - Chapel Hill, Duke, and North Carolina State University were involved from the very beginning. The Park’s compact geography placed businesses in close proximity to research institutions and to each other. This close proximity created the ideal conditions for the formal and informal network collaboration, idea exchanges, and competition that help a cluster thrive. The presence of these success factors, combined with a sufficient supply of affordable housing and an extensive and varied transportation infrastructure ensured the success of the RTP cluster.

³⁴⁹ http://www.rtp.org/files/Fact%20Sheets/overview_presentation.pdf Accessed on Jan. 2, 2008

³⁵⁰ Research Triangle Softball League. Accessed on Jan. 2, 2008 via http://wiki.rtp.org/uploads/2007_Information_Packet.pdf

³⁵¹ <http://www.rtp.org/main/index.php?pid=132&sec=3> Accessed on Jan. 2, 2008

³⁵² <http://www.smartcommute.org/AboutUs.htm> Accessed on Jan. 2, 2008

³⁵³ http://www.rtp.org/files/Fact%20Sheets/rtp_pedestrian_trails_102507.pdf Accessed on Jan. 2, 2008

Connecticut Maritime Cluster

Connecticut's maritime industry began to develop when the Electric Boat Company was founded in 1900 and other maritime companies grew around it.³⁵⁴ Electric Boat was one of the state's largest employers and formed the core of a thriving maritime industry.¹³² However, as other regions increased their port activity and the EPA began to strictly regulate the industry, Connecticut began losing revenue and influence within the maritime industry.³⁵⁵

The state's recession in the early 1990s prompted the Governor to take a new approach to economic growth. A meeting with 100 top executives and various surveys were distributed to determine the state's strengths and weaknesses.¹³² This initiative generated five advisory boards, and in 1998 they produced the *Partnership for Growth: Connecticut's Economic Competitiveness Strategy*.¹³² This report established the foundation for Connecticut's current economic development strategy, using Michael Porter's approach to create formal clusters to increase competition and growth.³⁵⁶ Connecticut was one of the first states to adopt an economic strategy of increasing growth and competition by intentionally developing industry clusters within the state.¹³²

The *Partnership for Growth II: A Competitiveness Agenda for CT* includes five categories of recommended goals to further the economic development of Connecticut's clusters.¹³² The first recommendation is to increase the competitiveness of the manufacturing industry, since this is where much of the state's employment is based. The report's second set of recommendations calls for maintaining a strong technology sector to help compete with high technology neighbors like Massachusetts. Connecticut also realizes that inner city revitalization will help attract and maintain businesses and customers to the area. Expanding business growth and improving safety and attractiveness of urban areas is the report's third recommendation. Next, Connecticut is focusing on increasing their economic base, which includes higher skilled workers, improved transportation infrastructure, low taxes and other business incentives, and high quality of life. Finally, public and private collaboration is addressed as an important aspect of growth and development in the clusters.³⁵⁷

In order to reach these goals, the state has created a Maritime Policy under the Department of Transportation. This policy calls for dredging Long Island Sound in order to maximize use of traffic lanes for goods and passengers.³⁵⁸ The Maritime Policy also provides funding for technologically advanced methods of removing sediment from the Sound, and calls for interconnecting multiple modes of transportation in order to increase

³⁵⁴ *Partnership for Growth II: A Competitiveness Agenda for CT*. March 2004. Accessed on Nov. 7, 2007 via http://www.youbelonginct.com/pupload/PforGreport_web.pdf

³⁵⁵ Connecticut Maritime Cluster Strategic Plan. December 2001. Accessed on Nov. 5, 2007 via ctmaritime.com/downloads/2002%20CLUSTER%20STRAT%20PLAN.doc

³⁵⁶ Connecticut General Assembly report, accessed on Nov. 7, 2007 via <http://www.cga.ct.gov/2000/pridata/Studies/DOT%20Final%20Chapter%20IV%20.htm>

³⁵⁷ *Partnership for Growth II: A Competitiveness Agenda for Connecticut*. March 2004. Accessed on Nov. 7, 2007 via http://www.youbelonginct.com/pupload/PforGreport_web.pdf

³⁵⁸ Accessed on Jan. 4, 2008 via <http://www.ct.gov/dot/cwp/view.asp?a=2314&Q=309828>

the access to and amount of revenue for water ports.¹³³ The Connecticut Maritime Coalition was established in 2004 to represent and unite maritime transportation organizations and agencies.³⁵⁹ The Commission evaluates and suggests various projects and policies to increase the productivity of the maritime industry.

The maritime industry relies on Connecticut's three main ports: New Haven, Bridgeport, and New London. The cluster has worked with local and state governments, along with private leaders, to increase port size and improve physical structure.¹³⁵ These ports are becoming increasingly limited in size and space, which has spurred the major effort to dredge these areas on Long Island Sound. Although Congress is responsible for funding the US Army Corp of Engineers' maintenance of channel depths, funding is often cut and the state has to supplement federal funding.³⁶⁰ Therefore, the Connecticut Maritime Commission (CTMC), the Department of Economic and Community Development (DECD), and the Department of Transportation (CONNDOT) have worked to regulate and fund the dredging projects. This collaboration has resulted in the LIS Dredged Material Management Plan and the receipt of federal funding for the Innovative Dredged Material Treatment project in Bridgeport. The collaboration also created dredging coordinator positions under the Transportation Bill.¹³⁶ In addition, in an effort to mitigate traffic on I-95, the Connecticut Maritime Coalition has helped create a Transportation Strategy Board to regulate the region's transportation flow.³⁶¹

The maritime cluster industry includes five sectors: transportation, manufacturing and services, recreation, commercial fishing, and the environment.³⁶² Currently, the Connecticut maritime industry includes about 349 small and medium sized companies, and employs more than 12,000 people.³⁶³ The DCED funds the campaign, *You Belong in Connecticut*. There are a broad range of efforts—all part of the *You Belong in Connecticut* campaign—to promote Connecticut's retention of well-educated and skilled workers, and to recruit and expand businesses.³⁶⁴ The state has also reduced taxes for businesses and decreased the sales tax for labor in shipyards and marine industry.³⁶⁵

The focus of Connecticut's cluster development strategy is to increase the availability of education and job training in the marine industry. The Connecticut Maritime Education Working Group works with local schools and colleges, including the University of Connecticut, to increase the availability of jobs and individuals who may be interested in working in the industry. The University of New Haven offers a program in marine

³⁵⁹ Connecticut Maritime Commission Annual Report 2006. Accessed on Jan. 3, 2008 via <http://www.ct.gov/dot/lib/dot/documents/dcmctc/a2006.pdf>

³⁶⁰ Connecticut Maritime Commission Annual Report 2006. Accessed on Jan. 3, 2008 via <http://www.ct.gov/dot/lib/dot/documents/dcmctc/a2006.pdf>

³⁶¹ "You Belong in Connecticut." Accessed on Nov. 7, 2007 via www.youbelonginct.com

³⁶² Connecticut Maritime Coalition Report, accessed on Nov. 7, 2007 via ctmaritime.com/downloads/CMC%20Final%20Report.doc

³⁶³ Connecticut Maritime Coalition, accessed on Nov. 7, 2007 via www.ctmaritime.com

³⁶⁴ *Partnership for Growth II: A Competitiveness Agenda for CT*. March 2004. Accessed on Nov. 7, 2007 via http://www.youbelonginct.com/pupload/PforGreport_web.pdf

³⁶⁵ Connecticut Maritime Cluster Strategic Plan. December 2001. Accessed on Nov. 5, 2007 via ctmaritime.com/downloads/2002%20CLUSTER%20STRAT%20PLAN.doc

biology,³⁶⁶ the University of Connecticut makes available undergraduate and graduate degrees in marine science,³⁶⁷ and the Coast Guard Academy in New London has three areas of specialization available in marine and environmental sciences.³⁶⁸ In New Haven, the Sound High School was founded to educate high school students who are interested in entering the aquaculture field.³⁶⁹

For the maritime cluster, government involvement played several roles in the success of the cluster. State government support began when the Governor and other officials assumed the champion role and laid the groundwork to intentionally develop industry clusters. The state's Competitiveness Agenda resulted in the creation of the Maritime Policy designed to maximize the economic potential of Long Island Sound and its major Connecticut ports. The state and local governments also engaged in network collaboration. Government organizations have partnered with each other and with private sector leaders to work on port improvement. Two state government departments and a commission collaborate to regulate and fund the dredging projects.

University and other educational institution involvement is focused on connecting youth to opportunities in the marine industries that take advantage of Long Island Sound's natural resource endowment. In particular, the Connecticut Maritime Education Working Group, which includes members from state government, maritime businesses and higher education institutions, works with universities and high schools to promote maritime training and education.

Energy Cluster – Houston, Texas

The petrochemical industry began in the Houston region with the discovery of oil on January 10, 1901, in the Spindletop oilfield.³⁷⁰ By 1902, more than 500 companies had migrated to the area, hoping to profit from oil production or related industries.³⁷¹ After 1902, the industry dwindled until post World War II, when the changing economy and greater uses for oil and oil products increased demand.¹⁴⁶ Renewed development of the industry in the 1950s resulted in the discovery of new oil fields and an increase of employment and economic growth. Since 1990, however, US proven oil reserves have declined by approximately 20 percent.³⁷²

This decline has had a significant effect on the Houston area, where 48 percent of employment is related to the energy industry.³⁷³ The industry has been divided into three sectors: oil and gas; electricity, coal, and nuclear sources; and renewable and sustainable

³⁶⁶ <http://www.newhaven.edu/show.asp?durki=33> Accessed on Nov. 16, 2007

³⁶⁷ <http://www.marinesciences.uconn.edu/> Accessed on Nov. 16, 2007

³⁶⁸ <http://www.cga.edu/display.aspx?id=519> Accessed on Nov. 16, 2007

³⁶⁹ The Sound School, accessed on Nov. 7, 2007 via www.soundschool.com

³⁷⁰ "Paths to Prosperity: Strategic Job Growth Parameters for 'Opportunity Houston' Through 2015." The Perryman Group. Accessed on Nov. 12, 2007 via

<http://www.opportunityhouston.org/pdfs/PerrymanReport.pdf>

³⁷¹ The Handbook of Texas, accessed on Nov. 12, 2007 via

<http://www.tsha.utexas.edu/handbook/online/articles/SS/dos3.html>

³⁷² <http://hypertextbook.com/facts/2000/SohailAhmed.shtml> Accessed on Jan. 9, 2007

³⁷³ www.houston.org Accessed on Nov. 7, 2007

energy³⁷⁴. The industry has devoted considerable research and development funding to market and advance the renewable resources sector in response to the recent decline in oil and gas production. An Energy Workforce Council was suggested to evaluate the industry workforce and to attract human capital to the region, and the Energy Advisory Group provides consultation and advice while advancing networking and communication.³⁷⁵

In October of 2004, Texas governor Rick Perry announced an economic strategy that would focus on the development of six industry clusters in the state, and would use existing business development to generate economic growth.³⁷⁶ The Office of the Governor, the Economic and Tourism Division, and the Texas Workforce Commission collaborated to create teams for each cluster, consisting of private, business, and government leaders. The teams were then instructed to complete a competitive assessment, and determine the resources and funding each industry needed from the state. The energy cluster determined that natural resources and expertise are its greatest strengths, and that the industry should focus on marketing and research and development of natural energy sources.¹⁵¹

The instability and variability of the oil and gas industry has led to advancement in other areas of the energy industry, specifically renewable and sustainable resources. Currently, Texas is the largest producer of wind energy in the nation.³⁷⁷ Since oil and gas prices have historically been so volatile, the energy industry has adopted renewable and sustainable resources into their cluster initiative. British Petroleum also announced in 2006 that they would place their alternative energy headquarters in Houston, showing their commitment to the region.³⁷⁸

The Bauer College of Business at the University of Houston has established the Global Energy Management Institute to inform and prepare students for involvement in the energy cluster.³⁷⁹ The University of Houston has also worked with the Department of Energy (DOE) to research and develop opportunities for renewable energy resources.³⁸⁰ The Lone Star Wind Alliance is a collaboration among the University of Houston's Cullen School of Engineering, Texas A&M University, the University of Texas at Austin, and other neighboring universities. This partnership has focused on increasing the innovative efforts and funding for renewable energy, and works to obtain state and federal support.¹⁵⁵

³⁷⁴ Texas Energy Cluster report accessed on Nov. 12, 2007 via

<http://www.texasindustryprofiles.com/PDF/twcClusterReports/TexasEnergyCluster.pdf>

³⁷⁵ Texas Energy Cluster report accessed on Nov. 12, 2007 via

<http://www.texasindustryprofiles.com/PDF/twcClusterReports/TexasEnergyCluster.pdf>

³⁷⁶ Office of the Governor, Cluster Industry Initiative. Accessed on Nov. 14, 2007 via

http://www.governor.state.tx.us/divisions/press/initiatives/Industry_Cluster/Industry_Cluster_SP/

³⁷⁷ "Alternative Energy in the Houston Region." Greater Houston Partnership. Accessed on Nov. 14, 2007 via <http://www.houston.org/blackfenders/16BW035.pdf>

³⁷⁸ <http://www.bp.com/genericarticle.do?categoryId=7014&contentId=7026292> Accessed on Jan. 8, 2007

³⁷⁹ <http://www.bauer.uh.edu/gemi/> Accessed on Jan. 9, 2007

³⁸⁰ <http://www.uh.edu/news-events/archive/nr/2007/06june/062507windcenter.html> Accessed on Jan. 9, 2007

Texas has been experiencing a “demographic cliff” in recent years. Baby boomers are preparing for retirement, the state has an elevated high school dropout rates, and new professionals are not replacing those leaving the industry.³⁸¹ The Texas Industry Cluster Initiative identified workforce challenges as “the single greatest factor that will limit job creation and capital investment in the Texas energy industry of the future.”³⁸² This *Cluster Report* also identified a lack of employees with skills needed for industry development, and showed that there are not enough employees with adequate skills; therefore companies are forced to compete for workers. Because many of the industry professionals have typically been foreign-born, there has also been a sharp decline in the industry workforce due to the strict immigration laws implemented recently.

Michael Porter’s Cluster Mapping Project highlights the lack of an overarching cluster organization for the Houston energy industry.³⁸³ Without an agency or organization to provide opportunities for networking, it is more difficult for the cluster to utilize the information resources needed for growth. Business collaboration and informal networking were not given much preference by leaders in the industry, according to surveys and interviews in the state.³⁸⁴

A factor contributing to the success of the Houston energy cluster was the ability to take advantage of a natural resource endowment of renewable and sustainable energy sources and the economic experiences gained from another natural resource endowment: petrochemicals. This cluster provides another example where the state assumed the interest champion role. In this case, the Governor launched a strategy to develop six industry clusters throughout Texas. The Governor’s office collaborated with the Economic and Tourism Division and the Texas Workforce Commission on Energy Cluster development. The Energy Cluster also benefited from the US DOE’s collaboration with the University of Houston on renewable energy research and development. However, all of these efforts have been insufficient in maintaining a strong and thriving energy cluster. This case study is an example of a cluster that developed based on a non-renewable natural resource which is too unpredictable to be depended on. The absence of informal networks and strong university involvement has left companies within the industry competing for employees who often are low-skilled. While the state has played a large role in attempting to revive the cluster, it remains relatively stagnant.

Pittsburgh Life Science Greenhouse – Pittsburgh, Pennsylvania

In the spring of 2001, the University of Pittsburgh and Carnegie Mellon University collaborated to propose the BioVenture initiative, which called for the growth and

³⁸¹ Texas Industry Cluster Initiative: Briefing Document. Accessed on Jan. 8, 2007 via http://www.twc.state.tx.us/news/ti_crosscutting.pdf

³⁸² Texas Energy Cluster Report p. 5 accessed on Nov. 12, 2007 via <http://www.texasindustryprofiles.com/PDF/twcClusterReports/TexasEnergyCluster.pdf>

³⁸³ <http://www.isc.hbs.edu/MetaStudyTemplateHoustonOilAndGas.pdf> Accessed on Jan. 8, 2007

³⁸⁴ Texas Energy Cluster Report. Accessed on Nov. 12, 2007 via <http://www.texasindustryprofiles.com/PDF/twcClusterReports/TexasEnergyCluster.pdf>

development of the bioscience industry in the region.³⁸⁵ The BioVenture is expected to create 5,000 jobs over 10 years, and the endeavor will cost \$600 million.³⁸⁶ This project integrated community input into the plan's development by interviewing more than 120 people and conducting community sessions with individuals and organizations from the life science industry, academia, health services, economic development organizations and government officials.³⁸⁷ Their proposal was based on the previously established Pittsburgh Engineering Greenhouse, a successful engineering cluster in the region. In November of that same year, then Governor Tom Ridge allocated \$40 million to the initiative through the Tobacco Settlement, a multi-state program focused on tobacco use prevention.¹⁶⁰

Active partners and organizations, including the Pittsburgh BioVenture, University of Pittsburgh Medical Center, the Pittsburgh Regional Alliance, and business and government leaders agreed to integrate their ongoing efforts into what is now known as the Life Science Greenhouses.³⁸⁸ There are currently three Life Science Greenhouses in the state of Pennsylvania: Philadelphia, Harrisburg, and Pittsburgh. The goal of the Pittsburgh Life Science Greenhouse (PLSG) enterprise is to increase the size and productivity of the life sciences industry, and within a 10-year span, to make Pittsburgh the leader in the biosciences.³⁸⁹

University investments, especially those of the University of Pittsburgh and Carnegie Mellon, have made the bioscience industry growth extremely successful. Six regional universities graduated almost 8,000 science and engineering students in 2003, increasing the amount of relevant skills in the labor force. The University of Pittsburgh and Carnegie Mellon sponsor the Pittsburgh Nuclear Magnetic Resonance (NMR) Center for biomedical research,³⁹⁰ and work together on the Center for the Neural Basis of Cognition (CNBC) which develops methods and researches neural and cognitive abilities.³⁹¹ The NMR Center and the CNBC are instrumental in strengthening the research and innovation capacities of Pittsburgh's life science industry. A recent \$25 million dollar donation to Carnegie Mellon University from the Richard King Mellon Foundation will help the school play a larger part in the life science industry by providing funding for students and labs.³⁹²

³⁸⁵ Pittsburgh BioVenture/Life Sciences Greenhouse Prospectus. Oct 2001. Prepared by Technology Partnership Practice, Batelle Memorial Institute, Cleveland Ohio. Accessed on Nov. 2, 2007 via <http://www.pittsburghregion.org/public/cfm/homepage/pdf/BioVentureSummary.pdf>

³⁸⁶ "Pitt, CMU seek \$600 Million to Build up Biotech Industry" Nov. 11, 2001 Post-Gazette.com. Accessed on Jan. 7, 2007 via <http://www.post-gazette.com/businessnews/20011120bioven1120p2.asp>

³⁸⁷ "BioVenture/Life Sciences Greenhouse Aims to Develop Bioscience Industries" Dec. 5, 2001. *Carnegie Mellon News*. Accessed on Nov. 1, 2007 via http://www.cmu.edu/cmnews/011205/011205_bioventure.html

³⁸⁸ Pittsburgh Life Science Greenhouse website, accessed on Nov. 2, 2007 via http://plsg.com/index.php?option=com_content&task=view&id=12&Itemid=26

³⁸⁹ Pittsburgh Life Science Greenhouse website, accessed on Nov. 2, 2007 via http://plsg.com/index.php?option=com_content&task=view&id=12&Itemid=26

³⁹⁰ <http://www.cmu.edu/nmr-center/> Accessed on Jan. 7, 2007

³⁹¹ <http://www.cnbc.cmu.edu/> Accessed on Jan. 7, 2007

³⁹² "CMU Given Big Grant for Life Sciences" 10/23/2007. *Pittsburgh Post Gazette*. Accessed on Jan. 7, 2007 via <http://www.post-gazette.com/pg/07296/827683-298.stm>

The University of Pittsburgh created a Center for Industry Studies in 2001 to facilitate communication and interactions between faculty and industries.³⁹³ The Center is meant to emphasize the importance of relationships between academia and business when planning and developing industries. The Center includes individuals from backgrounds in economics, business, labor relations, and engineering, among others. Therefore, “[the Center] hope[s] to build partnerships that yield educational opportunities and promote economic development.”³⁹⁴

Venture capitalists have also invested close to \$100 million in the cluster, and federal research and development spending in the region exceeds the national average.³⁹⁵ Healthcare and life science jobs have grown 12 percent in Pittsburgh, compared with 7 percent nationally from 1999 to 2004.³⁹⁶ Greenhouse interim CEO Donald Smith Jr. stated that “the job growth experienced by the local life sciences industry sector puts the Greenhouse ahead of its initial goal of creating 1,000 regional jobs in its first five years of existence.”³⁹⁷ The EPA has given a grant to Carnegie Mellon for a Brownfields Job Training program, and a Development Demonstration Pilot, which gives scholarships to low income individuals and helps with job placement after training.³⁹⁸

Organizations like the PLSG have ensured that small, start-up companies have the resources they need to flourish. They have established a program called the Executive-In-Residence program, which employs experts and executives to provide advice and strategies to new and mature businesses.³⁹⁹ The PLSG also provides financial support to university and research programs to accelerate the growth and innovation of these centers. The Pittsburgh Technology Council unites businesses within dominant industries, including life science, and establishes networks for each industry.⁴⁰⁰ The life science network encourages industry members to socialize and share information through lectures and other events throughout the year.

Between 1999 and 2003, Pittsburgh has experienced a 51 percent growth in research and development expenditures, which reached \$647 million in 2003.⁴⁰¹ The 10-year plan proposed to create 5,000 new jobs in the bioscience industry, and the start-up of 110 new

³⁹³ <http://www.industrystudies.pitt.edu/index.html> Accessed on Jan. 7, 2007

³⁹⁴ <http://www.industrystudies.pitt.edu/sloanindustrystudies/index.html> Accessed on Jan. 7, 2007

³⁹⁵ Porter, Michael E. “Clusters of Innovation Initiative: Pittsburgh.” Accessed on Oct. 29, 2007 via http://www.compete.org/pdf/pittsburgh_ex.pdf

³⁹⁶ “Job Creation in the Pittsburgh Region.” Pittsburgh’s Future. Accessed on Jan. 7, 2007 via <http://www.pittsburghfuture.com/economy.html#industries>

³⁹⁷ Greenhouse interim CEO Donald Smith Jr. in article “Greenhouse Launches Two Life Sciences Funds” *Pittsburgh Business Times*, Nov. 14, 2003. Accessed on Jan. 7, 2007 via <http://www.bizjournals.com/pittsburgh/stories/2003/11/17/story2.html>

³⁹⁸ “Carnegie Mellon Creates Biomedical Engineering Department To Meet Demands of a Growing Biotechnology Industry” Sept. 9, 2002. *Carnegie Mellon News* accessed on Oct. 31, 2007 via http://www.cmu.edu/PR/releases02/020909_bioeng.html

³⁹⁹ Pittsburgh Life Science Greenhouse website, accessed on Nov. 2, 2007 via http://plsg.com/index.php?option=com_content&task=view&id=12&Itemid=26

⁴⁰⁰ <http://www.pghtech.org/Networks/life/> Accessed on Jan. 7, 2007

⁴⁰¹ Pittsburgh Life Science Greenhouse website, accessed on Nov. 2, 2007 via http://plsg.com/index.php?option=com_content&task=view&id=12&Itemid=26

companies. As of 2004, there were 3,229 life sciences firms counted throughout southwestern Pennsylvania, employing a total of 115,000 people.¹⁷⁷ The life science cluster's total payroll for that year was \$560 million, and the average salary was about \$56,700 which is well above the national average.⁴⁰² The plan also projected that a total of \$330 million would be invested in the region.⁴⁰³

Pittsburgh area universities were significantly involved in all of the factors that led to PLSG success. The University of Pittsburgh and Carnegie Mellon University were the interest champions of the BioVenture initiative, which spun off the PLSG. The involvement of these universities has also included major financial investments and contribution of a large number of skilled graduates to the bioscience workforce. University participation has also dominated the networks and collaboration success factor. The University of Pittsburgh's Center for Industry Studies facilitates communication and interactions between faculty and industries. Government involvement has also led to a strong facilitation of federal research and development grants and funding for the region.

⁴⁰² Porter, Michael E. "Clusters of Innovation Initiative: Pittsburgh." Accessed on Oct. 29, 2007 via http://www.compete.org/pdf/pittsburgh_ex.pdf

⁴⁰³ "BioVenture/Life Sciences Greenhouse Aims to Develop Bioscience Industries" Dec. 5, 2001 [Carnegie Mellon News](http://www.cmu.edu/cmnews/011205/011205_bioventure.html) accessed on Nov. 1, 2007 via http://www.cmu.edu/cmnews/011205/011205_bioventure.html

Chapter 2 – Chemical Warfare Remediation

Villanova University, Dr. Randy Weinstein

Overall Design

In the proposed project we planned to develop a universal method for quick deactivation and removal of chemical pollutants in water. This method would not depend on identifying specific contaminants in water, but rather just the fact that a chemical pollutant is present. The method of deactivation would need to occur within 24hrs of deployment; nothing that further post treating of by products formed may be required.

To test our system of neutralization of warfare and chemical contaminants in water (fresh and aqueous) we studied two nanoparticles' (TiO₂ and ZnO) effectiveness at neutralizing and destroying aqueous solutions of chemicals of interest. We selected three carbon based chemicals to use as model contaminants for our initial studies:

- m-Dinitrobenzene, a compound released in water during chemical explosive manufacturing and structurally similar to many explosives.
- Dimethyl methylphosphonate, a chemical warfare nerve agent surrogate.
- Thiodiglycol, a building block for many pesticides and similar to chemical warfare agents.

We believe that if we are first able to neutralize these three contaminants which contain a variety of chemical functional groups, that we could then spend future years testing more compounds which are structurally similar to other warfare and chemical contaminants of interest to further validate the neutralization process.

Initial Results

We studied the model contaminate destruction by exposing aqueous solutions of these chemicals to our TiO₂ and ZnO nanoparticles. These compounds were studied individually at different concentrations levels in both fresh and salt water in the laboratory. We varied the particle size and amount of each nanoparticle used and also explored the effect of pH, co-solvent, temperature, and UV light exposure on the destruction process. Original testing began with *m*-dinitrobenzene (DNB). Control experiments confirmed that over a 24 hour period DNB did not degrade in fresh or salt water even when exposed to simulated sunlight without the presence of nanoparticles. Also, it was confirmed that TiO₂ in an aqueous solution of DNB did not degrade the DNB. ZnO degraded about 10-15% of the DNB without sunlight.

Some results with turbid (dirty) water were also found. We also tested that dilute hydrogen peroxide as well as purging all the oxygen out of the water with nitrogen had no effect on DNB degradation. Hence the amount of dissolved oxygen in the water will

not be critical for the destruction of DNB, extra oxygen (provided by hydrogen peroxide) or displacement of oxygen with nitrogen had no effect on DNB destruction. Our final test was to confirm that sea water was also a viable solvent for DNB destruction. We mixed our own solution of sea water from mineral salts to match those found in nature. We found the TiO_2 had slightly slower destruction rates while the ZnO had little change. Identification of the byproducts formed was initiated to help increase our understanding of the destruction chemical pathways, but significant progress on this identification has not occurred to date.

The experiments indicated that sunlight was required for any significant degradation. This can be accomplished naturally or with artificial UV light if sufficient sunlight is not available. However, from all of the results we achieved with fresh water, sea water, and dirty water, it appears that we can easily get DNB destruction by either TiO_2 or ZnO nanoparticles in solution with the exposure to sunlight. No high powered UV sources were required. Our preliminary results showed that with exposure to sunlight, these nanoparticles can effectively neutralize the three model contaminants; however, complete oxidation to carbon dioxide, water and mineral salts is not always achieved in less than 24 hrs. In other words, after short exposure time, even if all of the starting material has been neutralized, some byproducts do remain which need to be treated or removed from solution. Therefore, we are proposing the use of carbon nanofibers as catalyst supports for the nanoparticles to increase their catalytic activity in hopes of further oxidizing byproducts and unreacted materials. In addition, these fibers will also be used as direct adsorbents to remove chemical contaminants and byproducts from water. Our future studies are focused on the use of the nanofibers as these fibers should not only alter and improve the neutralization efficiencies but they should also act as adsorbents themselves. Their ability to remove the initial contaminants as well as byproducts formed will be explored as a function of the processing conditions (temperature, pH, salinity, concentration, UV light, etc.).

Typical Experimental Test

Currently we have initial testing of the destruction of the three model contaminants in water with exposure to sunlight. For simplicity, the results of the *m*-dinitrobenzene (DNB) neutralization will be discussed as similar procedures are used for each compound. For a standard test we first soak clear photo vials in 10% HCl solution for at least an hour to remove any residual contaminants from the glass surface. Next we place 0.01 g of nanoparticles (TiO_2 or ZnO) in each photovial and add 10 mL of 0.05 g/L solution of DNB in water (fresh or salt). Each photovial is covered with aluminum foil that has been cleaned with hexane to suppress any light catalyzed reaction until the start of an experiment. The photovial is capped and ready for use.

A typical destruction curve is shown in Figure 10 for DNB destruction with ZnO with sunlight illumination. We used our standard reaction conditions of 50 mg/L of DNB in fresh water with a nanoparticle loading of 1 mg/mL. As can be clearly seen from Figure 10, there is rapid destruction of DNB without any harsh chemical processing or exotic conditions required. The TiO_2 particles were 21 nm in diameter with a surface area of 50 m^2/g while the ZnO were 50-100 nm in size with a surface area of 15-25 m^2/g . These

sizes were selected as ones that were commercially available and relatively inexpensive. Future studies are planned to explore the effect of particle size on destruction efficiencies and rates.

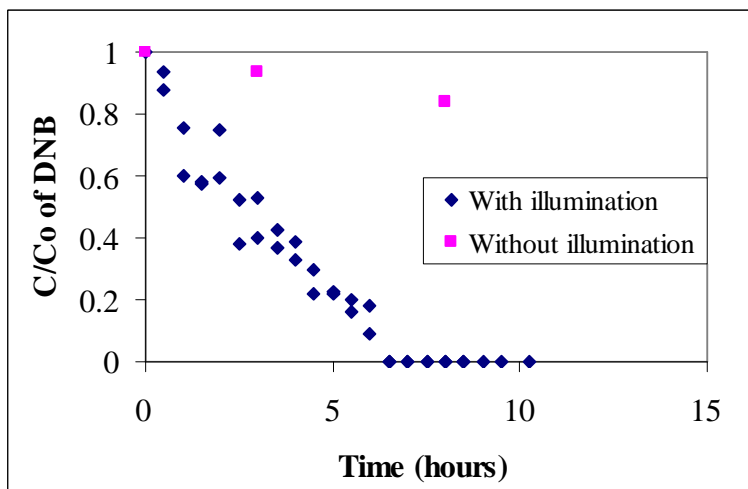


Figure 10: DNB destruction with and without illumination in the presence of ZnO particles in fresh water

For a typical experiment we place 32 photovials in the shaker under the UV lights in our sunlight simulator. After fixed intervals of time, photovials are removed and the contents transferred to amber vials and await analysis. Five mL of toluene is added to each amber vial to extract the DNB into the organic phase, which is placed in a vortex to enhance contacting between the phases. The phases separate and are centrifuged, if needed, to remove the nanoparticles before analysis. The toluene phase may be diluted to give a DNB concentration within the operating range of the electron capture detector (ECD) on the gas chromatograph (GC). Typical dilution is 5 μ L of toluene phase with 1 mL of toluene for injection into the GC.

Top Level Design

On a fast response ship there would be a container (whose size still needs to be determined) of a carbon nanofibers and/or nanoparticle material which would be ready for deployment into any water system. There would need to be mechanical methods for delivering the contents of the container to the water. In addition, UV light sources would be required to illuminate the water when sunlight is not sufficient. After a fixed exposure time, a scoop and filter system would need to be used to remove the materials from the water and stored as hazardous waste on board the ship.

Chapter 3- Genomics And Microarray Unit For Rapid And Accurate Onsite Identification Of Pathogens

Villanova University, Dr. Metin Duran, Timur Dunaev, and Sevda Alanya

Introduction

Rapid onsite detection of pathogens in water environments remain as one of the major challenges in eco-toxicology, public health maintenance, and, more recently, bioterrorism prevention. This is partly due to the fact that conventional pathogen identification methods rely on culturing pathogens from water samples. Culture-based methods have two major drawbacks: 1) Some pathogens may not be culturable and thus they are not detected by conventional technologies. 2) It may take days to culture and identify the pathogen and therefore timely response is impossible in many cases. Microarray technology or commonly referred to as “gene chips” have recently emerged as a highly innovative and promising technology for pathogen detection.

The overall goal of this study is to investigate the possibility of establishing a fully-functional genomics facility within an oceangoing decontamination system that can be used for rapid detection of microbial pathogens including bioterrorism agents. For that purpose, feasibility of two genotypic approaches for pathogen detection is evaluated: 1) A polymerase chain reaction (PCR) based pathogen identification; 2) microarrays.

The results of the first part, feasibility of using PCR-based pathogen identification were reported previously (see Systems Concept Report submitted in March 2008). The results showed that as effective as it is under many circumstances, PCR-based pathogen identification is not a feasible technology for on-site use in an oceangoing vessel. This is simply due to the fact that using this technology to screen for a large number of possible microbial pathogens might take a long time since each primer pair targeting particular species has to be analyzed independent of the primer pair targeting other species. Therefore efforts were concentrated on feasibility of microarray technology.

Identification of thousands of genes is possible using microarray technology. These so called gene chips, constructed on a 75x25 mm slide, can scan tissue samples for thousands of different genes simultaneously. It is an established technology in medical field to determine genetic reasons for diseases or possible therapies at gene level. However, microarray technology presents significant challenges when it is used for identification of microbial species. First of all, extraction and purification of genomic material from microbial cells is more difficult. Secondly, nucleic acids, particularly ribonucleic acid (RNA) have a very short half-life, making sample collection and preservation a challenging task on an oceangoing vehicle. The identification of certain pathogens requires RNA probes and considering that mRNA has a half life in the range of 20 seconds to 40 minutes, the challenge becomes quite formidable (Alifano et al., 1994). Lastly, the concentration of target genes in environmental samples is extremely low and therefore a pre-concentration or amplification step is required in order to have sufficient amounts of target genes for successful hybridization.

Since the beginning of 2008, the research team has made significant progress towards overcoming the biggest challenge in application of microarray technology by extracting intact nucleic acids, both DNA and RNA, from highly complex matrices such as ocean water and biosolids. The following sections provide the details of the recent breakthrough.

Background on microarray-based pathogen identification

The microarray technology is based on the principle of hybridization (hydrogen bonding) between complementary nucleotides that make up the genomic material, DNA or RNA. The complementary base pairing and other factors such as ionic strength, temperature, and solvents of the environment are the driving forces for hybridization. The technology is based on Southern blotting techniques. However, the current procedure is following Northern and dot blotting techniques more commonly. Microarrays today are created by robotic machines that arrange minuscule amounts of hundreds or thousands of gene sequences, or probes, on a single microscope slide or some form of a flexible membrane. Most recent microarrays contain up to 96,000 genes on a single 75x25 mm nylon membrane slide.

Microarrays for detection and identification of pathogens may be based on DNA or RNA. DNA-based microarrays have pathogen-specific DNA probes attached to them. These probes are complementary to a species-specific region of chromosomal DNA. Another approach is to fabricate microarrays using RNA probes that are complementary to one of the hyper-variable regions in the species 16S-rRNA. Latter approach is more commonly used in clinical microbiology and food safety fields since 16S rRNA based approaches are the golden standards for identification pathogens.

Regardless of nucleic acid used, successful application of microarray technology depends upon extracting sufficient quantities of uncontaminated and intact DNA or RNA from cells. In fact, that is the most challenging step limiting wider application of microarrays. When target cells are in complex matrixes such as ocean water, extraction of nucleic acids for upstream applications become even more challenging. Salt water is a highly complex microbial ecosystem with thousands of microbial species from the domains bacteria and Archaea, as well as with significant eukaryotic organisms. In addition, they have an enormously complex abiotic component interacting with microbial species. Naturally, such complexity makes it very difficult to isolate intact nucleic acids, particularly RNA, in the quantities necessary for amplification (Chen et al., 2006; Mangan et al., 1997; Mumy and Findlay, 2004; Rose et al., 2003; Sheridan et al., 1998; US EPA, 2005).

Materials and methods

Since extraction of intact nucleic acid, particularly RNA, is the “bottle neck” of using microarray technology for microbial pathogen detection, the research team had invested significant efforts on developing and optimizing a nucleic acid isolation and purification protocol. Several commercially available RNA extraction kits had been tested for their effectiveness in extracting intact RNA from biosolids and recently from ocean water.

The results are highly encouraging suggesting that the use of microarray technology on an oceangoing vehicle is possible.

The results on RNA extraction from biosolids were presented in the previous report (see Systems Concept Report submitted in March 2008). The same kit, MO BIO Laboratories' RNA PowerSoil™ Total RNA Isolation Kit, that was found to be most effective for extracting nucleic acid from biosolids, was used to extract nucleic acids from ocean water samples seeded with *E. coli* and *Salmonella sp.* after autoclaving. The protocol is based on phenol extraction, with proceeding capture-column purification. The protocol provided by the manufacturer was followed to extract RNA. The quantity and purity of extracted mRNA were determined by spectrophotometric analysis (A260 nm, A260/A280 nm, and A260/230 nm) using a NanoDrop™ 1000 spectrophotometer (Thermo Scientific, Wilmington, D, USA). Acceptable ranges for the purity at A260/280 nm and A260/230 nm are approximately 2.0 and 2.0-2.2, respectively. The integrity of RNA was analyzed on formaldehyde-denaturing agarose gel electrophoresis. "Agarose Gel Electrophoresis of RNA" protocol by Ambion® was slightly modified in order to increase the accuracy of the information on RNA yield. The protocol was adopted from Ambion® Denaturing Agarose Gel Electrophoresis of RNA supplemental protocol and changed as follows:

1. Prepare the gel:
 - Heat 1 g agarose in 72 ml water until dissolved, then cool to 60°C.
 - Add 28 ml of 10X MOPS formaldehyde buffer (Ambion® AM 8776)
 - Pour the gel using a comb that will form wells large enough to accommodate at least 25 µl.
 - Assemble the gel in the tank, and add enough 1X MOPS running buffer to cover the gel by a few millimeters. Then remove the comb.
2. Prepare the RNA sample and markers:
 - To 1-3 µg RNA, add 0.5-3X volumes NorthernMax® Formaldehyde Load Dye (AM 8551) to get the same volume for all the samples
 - Prepare an aliquots of 2 µg (2 µl) RNA Millennium™ Markers (AM7150) with 3X volume of NorthernMax® Formaldehyde Load Dye
 - Add ethidium bromide at a 50 µg/ml concentration (it is important to use the same amount of ethidium bromide in all the samples)
 - Heat denature samples at 65°C for 15 min.
3. Electrophoresis:
 - Load the gel and electrophorese at 5-6 V/cm until the bromophenol blue (the faster-migrating dye) has migrated at least 2-3 cm into the gel, or as far as 2/3 the length of the gel. After electrophoresis, each denaturing gel was visualized on a UV transilluminator to determine intactness of RNA.

The appearance of 16S and 28S rRNA bands on the gel was considered an indicator of intact RNA. In case gel electrophoresis results were questionable, due to indistinct rRNA band when extracted RNA is not in sufficient quantity, the samples were analyzed on an

Agilent 2100 Bioanalyzer (Agilent, Wilmington, DE, USA). During the bioanalyzer tests, presence of distinct 16S and 23S ribosomal peaks, the absence of smaller well-defined peaks between the two ribosomes, and the flatness of the baseline and absence of small rounded peaks between 29 seconds and 16S ribosome were taken as indicator for intact extracted total prokaryotic RNA.

Results and discussion

Figure 11 depicts extracted nucleic acid from three different ocean water samples: blank (autoclaved ocean water sample without seeding); autoclaved ocean water seeded with *E. coli*; and autoclaved ocean water seeded with *Salmonella*. Lane M represent the RNA marker (standard) while Lane 1 through 3 represent the ethidium bromide stained nucleic acids extracted from the autoclaved ocean water samples with no seeding (blank), seeded with *E. coli*, and seeded with *Salmonella*, respectively. Lane 4 through 6 represent the same samples after DNAase treatment that removes any DNA extracted along with RNA.

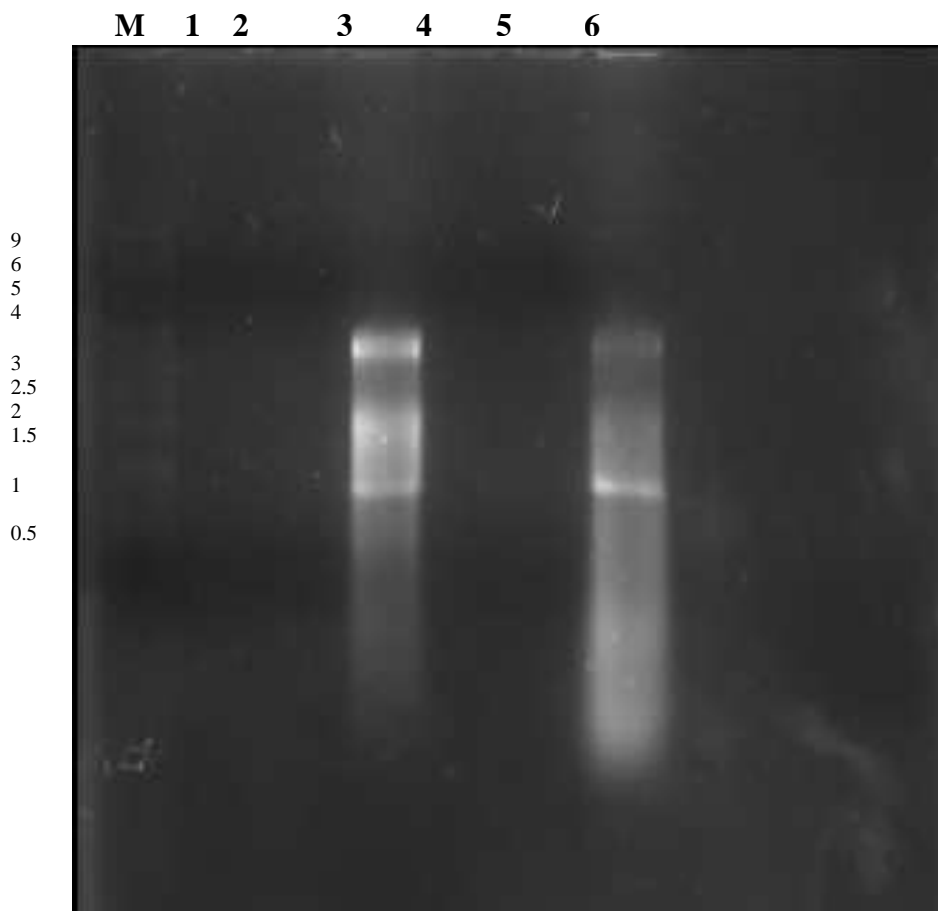


Figure 11: Formaldehyde denaturing agarose gel electrophoresis of nucleic acids extracted from the seeded ocean water samples.

In order to verify that RNA was extracted, all of the three samples were treated with DNAase A (Sigma-Aldrich, Location) after the extraction. Lane 4 through 6 show the samples treated with DNAase. In other words, the samples shown in Lane 5 through 6 contain only RNA since any DNA in samples are degraded by actions of DNAase.

Comparing samples in Lane 3 and 6, one clearly notices that the protocol is highly effective in extraction of clean (without DNA contamination) RNA from a complex matrix such as ocean water. Nucleic acid extracted from ocean water sample autoclaved and then seeded with *Salmonella* (Lane 3) basically showed no change after treatment with DNAase (Lane 6) indicating that the extraction solution was free from DNA, due most likely highly selective performance of the capture-column purification step. Two distinct bands in Lane 6, one about 3 kbp size and the other approximately 1 kbp, are likely to be 16S and 23S rRNA. Bands below 0.5 kbp are likely to be short messenger RNA pieces.

It should be noted that the results presented in Figure 11 are highly encouraging in terms of feasibility of using microarrays for pathogen identification. As mentioned earlier, extraction of sufficient clean and intact nucleic acid is the main challenge in applying the technology for pathogen detection and the research team has shown this challenge can be overcome. In order to verify that nucleic acids were extracted from the seeded ocean water samples, the quantity and integrity of the RNA were also tested using an Agilent 2100 Bioanalyzer (Agilent, Wilmington, DE), standard RNA integrity analysis. The bioanalyzer analyses were conducted at the Core Genomics Facility of the Wistar Institute, Philadelphia, PA. Figure 12 and 13 show the electropherograms of RNA extracted from seeded ocean water sample.

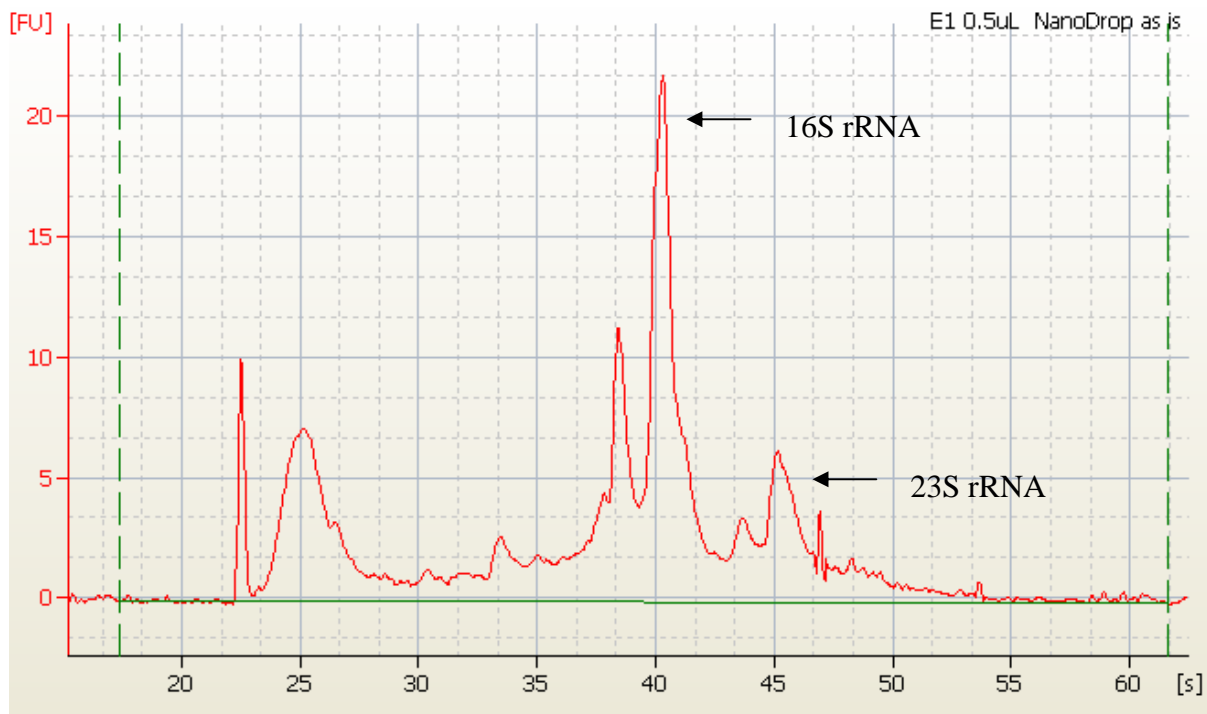


Figure 12: Agilent Bioanalyzer electropherogram of RNA extracted from ocean water spiked with *E. coli*.

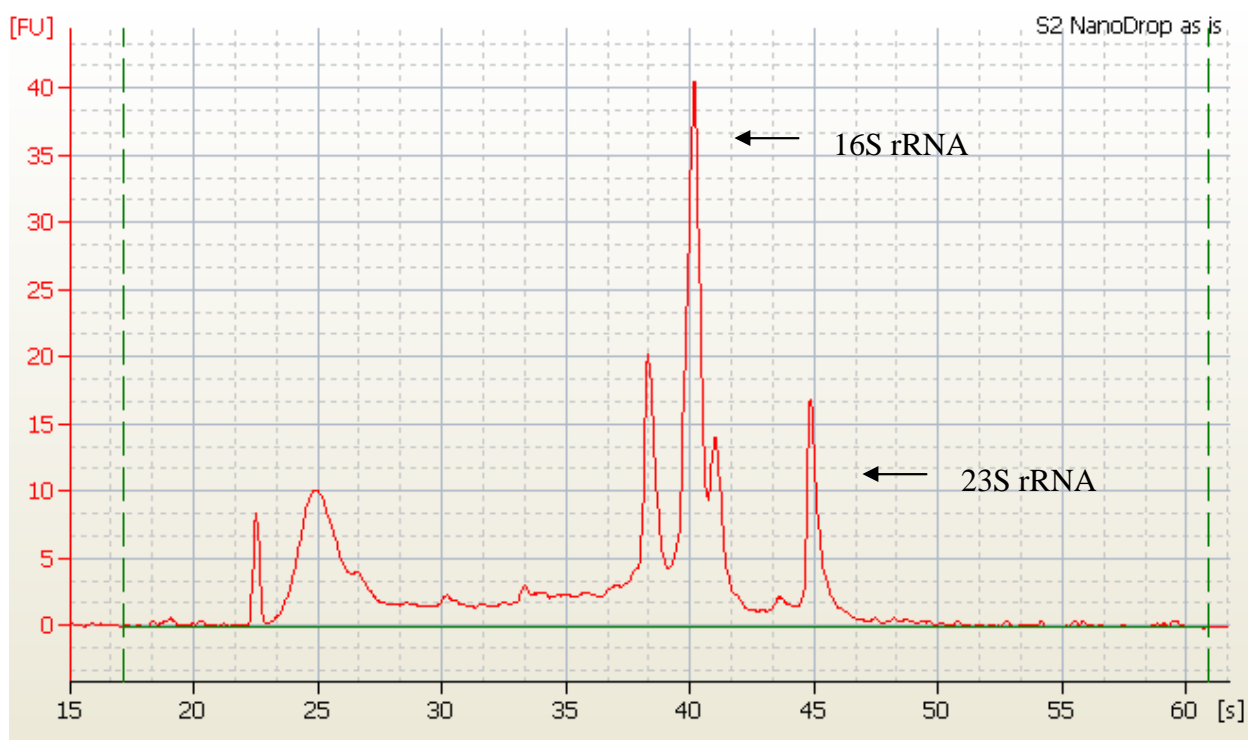


Figure 13: Agilent Bioanalyzer electropherogram of RNA extracted from ocean water spiked with *Salmonella* sp.

The significance of bioanalyzer results lies in bands labeled as 23S rRNA in Figure 12 and 13. The 23S rRNA peaks are the indicators of RNA degradation since 23S RNA is the first form of RNA that degrades during extraction or preservation of extracted samples. Shorter 23S rRNA peak in Figure 12, which shows RNA extracted from ocean water sample seeded with *E. coli*, and following jagged signal indicate that RNA is at least partially degraded. Although it is still possible to achieve good microbial identification from 16S RNA in that sample, partially degraded RNA may not be suitable for certain applications such as gene expression analysis. However, the sharp shape of the 23S RNA peak in Figure 13 and the smooth signal following it indicate that the RNA extracted from the other ocean sample seeded with *Salmonella* sp. is in perfectly intact condition, free of any degradation. Figure 13 strongly suggests that the extraction protocol developed during this study can successfully be used to obtain sufficient quantities of intact RNA from seeded ocean water samples. It is important to note that partial degradation of RNA extracted from the ocean water sample seeded with *E. coli* might have happened during transportation of the extracted RNA from Villanova to Philadelphia and it may not be an issue if samples could be analyzed on site immediately after extraction.

Conclusions and future directions

The results presented in this report strongly suggest that extraction of sufficient quantities of intact nucleic acid, both RNA and DNA, from a complex matrix such as ocean water is possible using commercially available extraction kits and optimized extraction protocols. This is a significant development since application of any genotypic method to

microbial identification in ocean water samples will require sufficient quantities of intact nucleic acid. The research team made significant progress towards overcoming this major challenge as evidenced by the results presented in this report. These findings indicate that a microarray-based pathogen identification approach is feasible on an oceangoing emergency decontamination vehicle. The following will be major activities for September through December 2008:

- Develop a list of potentially target pathogens of public health and bioterrorism threat.
- Develop a list of equipment and supplies needed to establish a genomics facility on an oceangoing vehicle.
- Develop a tentative plan, a proposal, for manufacturing the microarrays that would be kept in stock on the oceangoing vehicle. This would include list of genomic websites for determining gene sequences for the target pathogens and commercial entities that would undertake physical manufacturing of the microarrays.

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Chapter 4- Report on Top Level Designs

Villanova University, Dr. Rosalind Wynne

Overview

The finalized design concept presented for a gamma radiation detector is consistent with preliminary schemes. The components of the finalized system are highlighted.

Design for Scintillation Detection System

The design of a customized system for the gamma ray scintillator is finalized. The system will consist of a NaI(Tl) scintillator that is coupled to a microstructured optical fiber. The scintillated light (at $\lambda=415\text{nm}$) will be transmitted through the fiber to be amplified by a photomultiplier and then undergo signal processing. (See Fig.14) The effective attenuation that the photon experiences as it propagates along the fiber system is dependent on the scintillation wavelength as a result of the fiber material properties. A reduced effective attenuation can be achieved by transmitting the photon via an air transmission region such as the hollow core of the fiber that may lead to an exponential increase of photons surviving the fiber transmission process.¹ One advantage of this approach is to possibly minimize the radiation absorption losses that can attenuate and distort the scintillation light by using air-core MOFs. Air-core MOFs demonstrate a modified photonic band gap confinement such that the fiber can be designed to support the propagation of light of a desired spectral range along the air-core.^{2,3} (See Fig.15) This unique air guidance property may permit scintillation light to propagate through the air-core thereby avoiding the absorption that occurs at scintillation wavelengths in the solid-core region of a conventional optical fiber. This system may also offer the possibility of longer transmission fiber lengths such that the electronic signal processing equipment location can be remote from the radiation site avoiding both radiation and EM interference.

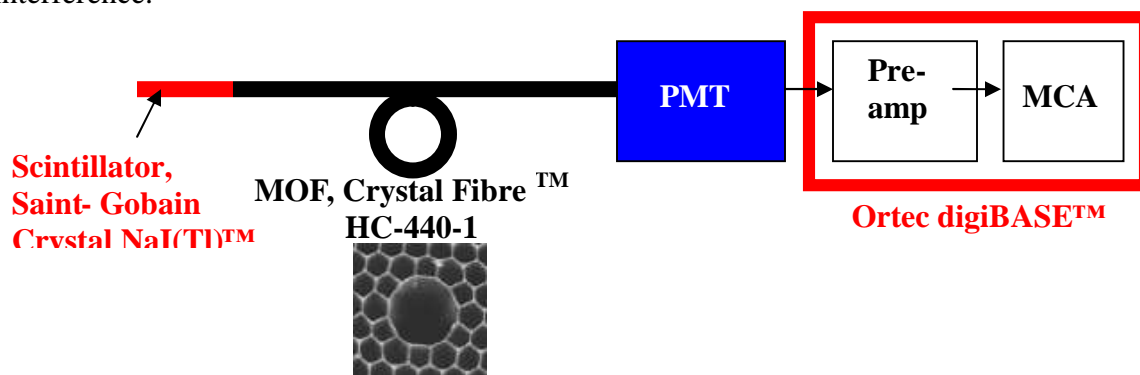


Figure 14: The gamma radiation detector concept.

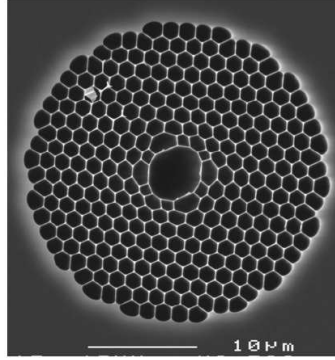


Figure 15: . Cross-section of a Crystal Fibre™ HC-440-01 ‘blue’ hollow core photonic bandgap fiber.⁴ The core diameter 4.9μm. The fibers has an 84μm cladding diameter.

The microstructured optical fiber has a transmission window such that the scintillated light could propagate through the air core with relatively low loss and low bend sensitivity. (See Fig.16) The probability⁸, $P(x)$, that a photon travels some distance x along the optical fiber away from its position of origin in the scintillator is

$$P(x)=A \exp(-\mu x)$$

where A is a constant that is a function of the geometry of the scintillator, μ is the effective attenuation the photon experiences as it propagates along the fiber system. The attenuation is dependent on the scintillation wavelength which is due to the fiber material properties. If the effective attenuation can be reduced by transmitting the photon via a low index or air transmission region, the likelihood of photons surviving the fiber transmission process may increase exponentially.

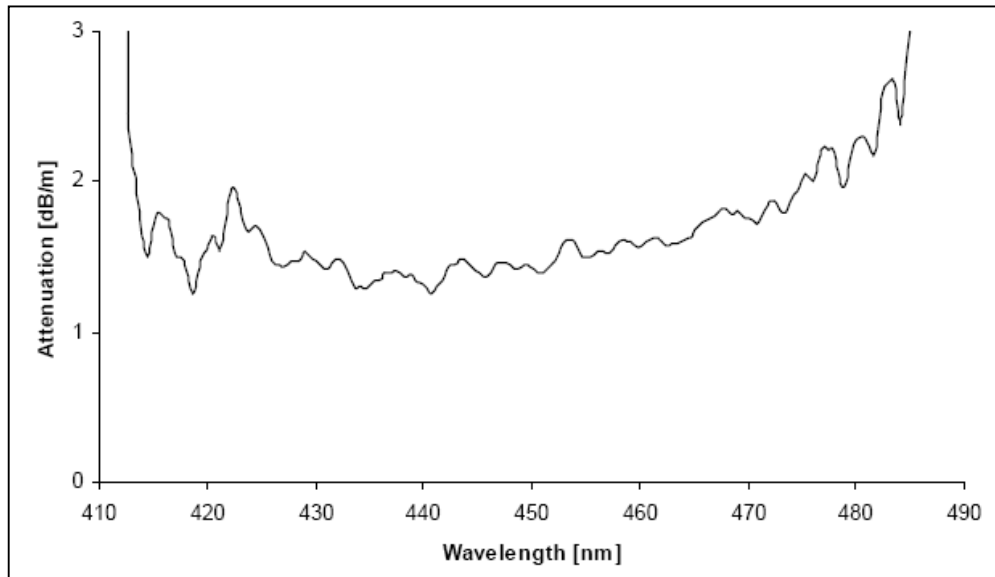


Figure 16: Typical attenuation for MOF Crystal Fibre TM HC-440-1⁵

Gamma rays are typically detected with scintillation detectors. The gamma radiation is converted into a light pulse. Efficient gamma ray scintillation detectors are large in size and are very dense. Thallium activated sodium iodide (NaI(Tl)) crystals are commonly used for gamma radiation detection. NaI(Tl) has a peak emission wavelength that is closely matched to the bialkali PMT sensitivity curve, (See Fig. 17 and 18) such that it produces a stronger signal than most other scintillation materials for an amount of energy absorbed. The preliminary system will be designed to detect gamma radiation from a ^{137}Cs sample. As ^{137}Cs decays it emits gamma radiation with energy 662 keV in addition to X-ray and beta ray energies. (See Fig.19)

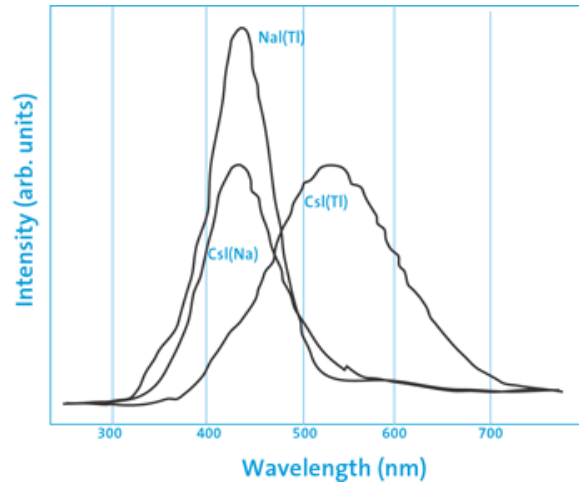


Figure 17: Scintillation emission spectrum of Saint-Gobain Crystal NaI(Tl)TM with a peak at 415nm.⁶

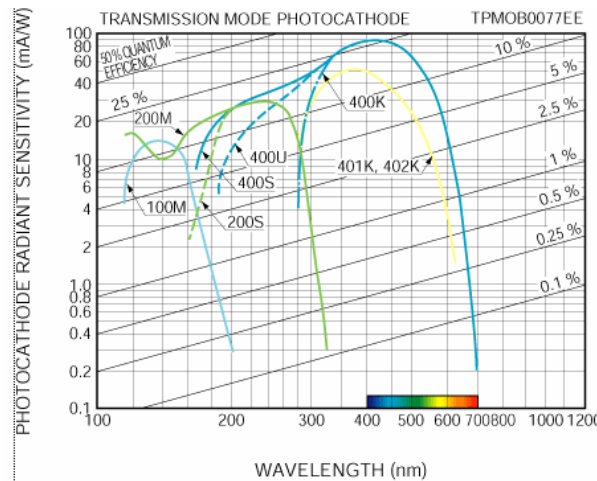


Figure 18: PMT spectral response of a HamamatsuTM R1635 PMT (spectral response curve 400K)⁷

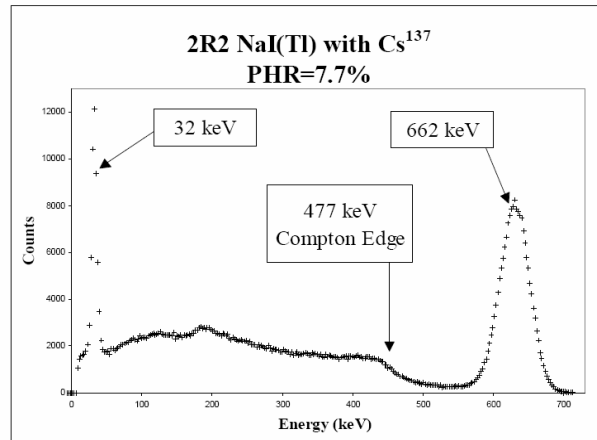


Figure 19: ¹³⁷Cs radioactive source measured with a 2"x2" NaI(Tl) detector.⁸

Basic Scintillation Scheme

The inorganic, thallium activated sodium iodide for gamma-ray detection (Saint-Gobain Crystal NaI(Tl)TM) scintillation material will be employed. A length of scintillating material will be cut and polished on the end face to promote light confinement to the scintillator core. The scintillator will be coupled to a length of unfilled length of hollow core fiber (Crystal Fibre HC-440-1TM) for low loss transmission of the scintillation light to the photodetector. The PMT (Hamamatsu-Photonics R1635) will produce an amplified electrical current in response to the scintillation signal. The electrical signal is preamplified (Ortec digiBASE) and sent to be analyzed with a multichannel analyzer (MCA). The system also has a graphic user interface for qualitative and quantitative spectrum analysis. (See Fig.20)

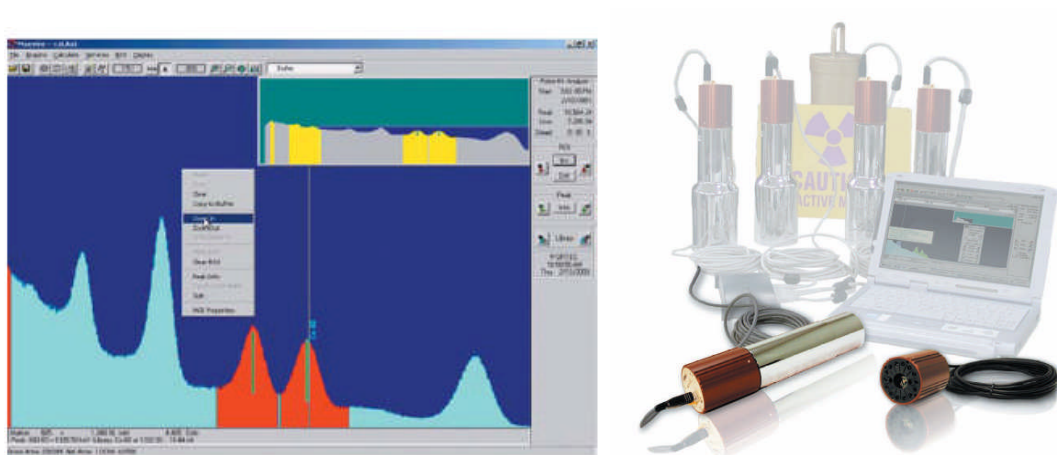


Figure 20: Typical Digibase spectral analysis and apparatus.⁹

Evaluation

The techniques discussed earlier allow for the composition of an all glass detection system that is nuclear radiation resistant and addresses the issue of signal degradation in glass by using an air-core light guide to transmit the scintillation signal to electronic processing equipment. The transmission length in the optical fiber is also increased by the introduction of an optical fiber amplifier to reduce the number of electronic processing stations. The detectors presented offer advantages such as ruggedness since they are not susceptible to nuclear radiation degradation, humidity, and drastic temperature variations which in addition to portability, make the all glass fiber nuclear detection system a good candidate for oceangoing vessels. Oceangoing vessels can be subjected to weather conditions of severely cold or hot climates with precipitation and it is important to have instrumentation, especially for ships with radioactive cargo, that have reliable nuclear detection without sacrificing cargo space. The detector components are also immune to electromagnetic interference from EMPs which may accompany nuclear attacks or accidental explosions. The detector offers added benefits such as being chemically non-corrosive and having the potential to be “connecterized” to allow for low-technical-level-skilled personnel to install and operate the system.

Conclusion

A compact, light weight, reliable optical fiber based nuclear radiation contamination detector would be beneficial to a seagoing decontamination system. A miniature nuclear radiation detector based on microstructured optical fiber technology will be developed. The detectors will sense neutrons and gamma-rays that are common radiation artifacts of weapons grade nuclear materials. Packaged detectors can be located aboard military vessels to monitor nuclear reactors that power ships and submarines, nuclear cargo, and nuclear warfare technology.

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